

Pertanika Journal of SOCIAL SCIENCES & HUMANITIES

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A special issue devoted to Physical Education and Sport Help Build Healthy Society

> Guest Editors Eng Hoe Wee & Ong Tah Fatt



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Preface

This publication is the outcome of the 3rd FIEP Asia Conference (ACPES2018) organized by the Faculty of Applied Sciences, Tunku Abdul Rahman University College (TARUC), Kuala Lumpur, Malaysia. The conference was held from 1-3 June 2018 at TARUC Kuala Lumpur Campus with the endorsement of FIEP Europe (Fédération Internationale D'Éducation Physique).

The theme of the conference "Physical Education and Sports Help Build a Healthy Society" was intended for participants to reflect on the important roles played by Physical Education and Sport in promoting health among individuals which made up the society. Hence, from the main theme, three sub-themes were decided as follows:

- Physical Education and Health
- Physical Activity and Community Health
- Sports and Health

We would like to express our sincere thanks to all the authors who contributed their research articles to make this publication possible. Special thanks are to all the reviewers, the editors, and the editorial board (Prof. Dr. Gurnam Kaur, Prof. Dr. Raj Subramaniam, Prof. Dr. Chee Keong Chen, Dr. Hui Yin Ler, and Ms. Wei Fong Cheng), the publisher, and those involved in the technical processes. We would also like to thank all, who contributed to the organization and helped to realize the conference with their support.

We sincerely hope that the papers of this Special Issue will contribute to the further development in Physical Education, Sport, and Physical Activity nationally and internationally.

i.

Guest Editors:

Eng Hoe Wee (Assoc. Prof. Dr.) Ong Tah Fatt (Assoc. Prof. Dr.) ii



SOCIAL SCIENCES & HUMANITIES

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Implementation of Physical Education Programme in Malaysian Primary Schools

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ABSTRACT

This is a cross-sectional research focused on research evidences regarding the implementation of Physical Education (PE) programmes in Malaysian primary schools based on the perceptions of primary school PE teachers. The sample consisted of 1276 teachers from 248 randomly sampled primary schools in Peninsular Malaysia. The survey instrument collected demographic data and four implementation dimensions (Teaching Ability, Administration of PE Programme, PE Class Distribution & Non-human Factor). Questionnaires were mailed to schools identified using the Ministry of Education Malaysia's master list and the response rate was 69%. The findings showed that there was a need to have specialist PE teachers as majority of the current teachers taught less than five PE periods per week and only 6.2% were PE majors. Independent sample t-tests conducted on teaching ability revealed that male teachers were more capable than female teachers in knowledge, managing and teaching sport and fitness activities and, detect and correct students' errors.

ARTICLE INFO

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E-mail address: weeeh@tarc.edu.my

ISSN: 0128-7702 e-ISSN: 2231-8534 On administration of PE programme, male teachers agreed more than female teachers that administrators organized in-house training, discussed PE teaching assignment, discussed factors affecting PE teaching, and observed PE teaching. As regards to class distribution, male PE teachers agreed more than female teachers that administrators had discussion with them before PE teaching assignment and assignment was based on interest and qualification. T-test results also revealed that there were no differences on perception of non-human factor statements. It is recommended that further research on solving PE human resource problems be undertaken. Specifically, greater attention should be given to in-house training and monitoring of the implementation of PE programmes.

Keywords: Administration of PE programme, non-human factor, PE class distribution, physical education, teaching ability

INTRODUCTION

Physical Education (PE) programme continues to contribute to the total growth and development of all children, primarily through movement (Pangrazi & Brusseau, 2014). Through its safe, supervised, and structured programmes, PE has fulfilled the need of children to acquire knowledge and engage in active behaviours, thus making them active and healthy (SHAPE, 2016). Effective PE programmes provide children with essential know-how to develop physically active lifestyles (Institute of Medicine [IOM], 2013). Consequently, these result in two major outcomes of PE, which are the cultivation of physical health and lifelong behaviours (Pangrazi & Brusseau, 2014).

When the 'UN International Year of Sport and Physical Education' has been proclaimed by UNESCO in 2015 (UNESCO, 2015), governments all over the world have recognized PE as a holistic subject. Despite the benefits and awareness, PE policy implementations have not been consistent among countries and Quality Physical Education (QPE) has not been implemented. Wee (2017) had outlined various strategies for QPE in Malaysia which among others included continuous efforts in improving the curriculum content of PE and teaching methods, ensuring adequate supply of PE teachers, monitoring quality teaching in PE, as well as providing adequate facilities, equipment and resources. Similarly, The Final Report of the World-wide PE Survey (UNESCO Final Report, 2013) had previously reported that to ensure teaching quality, PE teachers must be qualified and supported with administrative personnel and finance, adequate teaching resources, equipment and facilities, proper government policies and strong community partnerships.

As a non-examination subject, PE did not receive adequate attention from the Ministry of Education Malaysia. Numerous negative reports were published which identified elements such as unqualified teachers (Aboshkair et al., 2012; Chong & Salamuddin, 2010; Wee, 2013), inadequate facilities and equipment (Chong & Salamuddin, 2010; Syed Ali et al., 2014), and insufficient staff training programmes (Chong & Salamuddin, 2010; Wee, 2013). In addition, Wee (2013) reported that PE had often been replaced by other more valuable subjects.

Taking into account the short coming in implementing PE programme and its negative impacts on the health of primary school children, it is essential to investigate the PE programme in Malaysian primary schools. Conceptually, the implementation of the PE programme in primary school revolves around the four dimensions as shown in Figure 1.

The conceptual framework for the implementation of the PE programme is based on two factors that are human factors (administration of the PE programme, teaching ability and PE class distribution) and non-human factors. These two factors were noted by Malaysian researchers Siow and Wong (1983), Ahmad (1989), and Ahmad (1992) to be important factors in the implementation of the school curriculum and by Wee (2001) for the implementation of PE curriculum in the Malaysian context.

Research Problem

This study examined the implementation of primary school PE programme in Malaysia from the perception of PE teachers. UNESCO (2015) had reiterated that PE programmes were the most effective means of providing children with the skills, attitudes, values, knowledge and understanding for lifelong participation in society. Quality PE programmes (planned, progressive, inclusive learning experiences) are the foundation for children's lifelong engagement in physical activities and sports in providing children with psychomotor, cognitive social and emotional skills (afPE, 2008). Despite the positive values of PE programmes, its implementation in Malaysian primary schools is problematic.

Even though PE is a mandatory subject in Malaysian primary schools, its nonexamination status has diminished its importance as compared to other subjects in a Malaysian school culture which focuses on examination (Wee, 2013). PE has been neglected in the school curriculum and replaced under various circumstances in school, as compared to subjects with more economic values (Chong & Salamuddin, 2010). Dewi Mohamed et al. (2017) used the Malaysian Educational Quality Standard checklists (Ministry of Education Malaysia [MOEM], 2010)(score scale of 1 to 6) to examine 'leadership and vision', 'organizational management', 'management of curriculum, co- curriculum and sport, and



Figure 1. Conceptual model of the Implementation of PE programme in Malaysian primary schools

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student affairs', 'learning and teaching', and 'students' achievement' in 111 Malaysian primary schools and reported that 83.9% of the schools implemented PE at an average level, 6.3% at low level and 8.9% at high level. Similarly, in a study of 310 PE teachers in 155 primary schools, Syed Ali et al. (2014) revealed 'insufficient PE facilities' (M=4.20), 'over crowded field during PE classes' (M=4.46), 'insufficient funding' (M=4.33) and 'inappropriate PE class schedules' (M=4.66) were among the constraints of implementing PE programmes.

The above-mentioned reports raised issues of implementation of Malaysian PE programme. And that warranted the examination of primary school PE programme.

Hypotheses

Below are the null hypotheses formulated for the current study:

- 1. There will be no significant difference in the mean teaching ability perception scores according to gender.
- 2. There will be no significant difference in the mean Administration of PE Programme perception scores according to gender.
- 3. There will be no significant difference in the mean perception scores on class distribution according to gender.
- 4. There will no significant difference

in the mean perception scores on non-human factors according to gender.

METHODS

This study is a survey research designed to obtain research evidence concerning the implementation of PE programme from all government-aided primary schools in Peninsular Malaysia.

Participants

A total of 1276 full-time PE teachers from 248 government-aided primary schools in Peninsular Malaysia participated in this study. Slightly more female participated in this study [female (50.2%, n=641), male (49.8%, n=635)]. Majority of PE teachers were young (76.8% below 40 years in age, n=980). Almost 94% (n=1197) of them were non-PE majors and 6% (n=79) was PE majors. Almost 71% (n=904) of the PE teachers taught <5 periods of PE per week but taught >16 periods per week for other subjects. Majority of them had never attended PE courses (89%, n=1136) and sport related courses (92%, n=1174) since becoming a teacher.

Procedures

Sampling. A sample of 358 governmentaided primary schools which offered a standard national PE curriculum were randomly selected using stratified random sampling from 5138 schools listed in MOEM school registry. The schools were from the twelve states in the Peninsular Malaysia. A total of 248 schools responded, which constituted a 69% response rate.

Instrumentation. The instrument consisted of two sections. Section A: Personal Data. The items relate to gender, age group, field of specialization, teaching work load, in-house training programme, PE and sport courses attended. Section B: Implementation of PE programme [IOPEP] (Wee, 2001). The survey instrument used in this study consisted of four implementation dimensions. The items in this section related to Teaching Ability (9 items, $\alpha = 0.8737$), Administration of PE Programme (7 items, α = 0.8069), PE Class Distribution (5 items, α = 0.8047), and Non-human factors (6 items, $\alpha = 0.7433$).

Data Collection and Analysis

Data in this research were collected through mail survey. PE teachers completed questionnaires on paper and returned them via their schools. Items on the 'administration of PE programme' and 'PE teaching duty allocation' were assessed using a 5-point Likert Scales: Almost Always (5), Frequently (4), Occasionally (3), Rarely (2), Almost Never (1). Items of 'teaching ability' and 'non-human factors' were measured through Likert scale of Strongly Agree (5), Agree (4), Undecided (3), Disagree (2), Strongly Disagree (1). Descriptive statistics such as means, standard deviations, percentages were used to report the data from the questionnaire. Four independent t-tests were administered to determine whether differences existed in the perception

mean scores with 'Teaching Ability', 'Administration of PE Programme', 'PE Class Distribution', and 'Non-human Factor' as dependent variables and gender as independent variable. All t-tests were conducted using IBM SPSS for Windows (ver.21) with 0.05 significance level.

RESULTS AND INTERPRETATIONS

The examination of the implementation of PE programme focused on four critical factors that influenced its implementation which were 'Teaching Ability', 'Administration of PE Programme', 'PE Class Distribution', and 'Non-human Factor'.

Teaching Ability and Inadequacy of Specialist PE Teachers

Teaching ability was assessed through nine statements as shown in Table 1. The PE teachers agreed ('*strongly agreed' and* '*agreed'*) that they could manage their class (85.2%), could teach sport skills (60.9%), could manage fitness class (62.4%), 65.1% could detect and 60.1% could correct students' weaknesses. However, only 55.9% agreed that they had knowledge to teach PE, and only 8.9% 'can teach gymnastic skills'. More importantly they felt the need to attend PE courses (66%), and in-house exposure (76.3%) before handling the subject.

Inferential statistics revealed that there were no significant gender differences in terms of the need to attend PE courses (t(1274)=0.79; p=0.43) and in-house exposure before teaching PE (t(1274)=0.19; p=0.84).

T-test analyses of the mean scores for perception of ability to teach PE showed that male and female PE teachers differed significantly in their perceptions of their ability to teach PE in six aspects of 'I am equipped with PE pedagogical knowledge' (t(1274)=4.61; p=0.01), 'I can handle my students during PE class' (t(1274)=2.23; p=0.03), 'I can teach sports skills' (t=5.39; p=0.01), 'I can manage fitness activities' (t(1274)=2.81; p=0.01), 'I can detect my students' weaknesses' (t(1274)=3.55;p=0.01), and 'I can correct my students' weaknesses '(t(1274)=3.95; p=0.01). Mean scores showed that male teachers perceived themselves as more capable than female teachers in the six aspects. Both male and female teachers ($M_{\text{male}} = 2.41, M_{\text{female}} = 2.30$) expressed reservations on teaching of gymnastic.

Administration of PE Programme

Data in Table 2 showed 54.4% of the administrators 'frequently' and 'always' presumed that PE was essential. This presumption was supported by the fact that only 36.2% of the administrators 'frequently' and 'always' had discussion with teachers before assigning them to teach PE. Similarly, it was noted that 73.1% of administrators 'never', 'rarely' and 'occasionally' deliberated about factors affecting the teaching and learning of PE with teachers. In addition, PE had inferior position among the school subjects; 84.7% of administrators 'never', 'rarely' and 'occasionally' plan inhouse training programme for staff.

On facilities for PE, PE teachers perceived that 56.2% of administrators *'frequently' and 'always* 'allocated adequate funding for PE facilities. Almost 68% of

Table 1

| Teachers' | perception on | their ability to | teach Physical | Education |
|-----------|---------------|------------------|----------------|-----------|
| | , , | 2 | 2 | |

| Statements | | Percei | ntage A | nt | М | SD | |
|--|------|--------|---------|------|------|-----|------|
| | SA | A | U | D | SD | _ | |
| I am equipped with PE pedagogical knowledge. | 3.8 | 52.1 | 25.7 | 14.7 | 3.7 | 3.4 | 0.91 |
| I can handle my students during PE class. | 16.0 | 69.2 | 11.9 | 2.8 | 0.1 | 4.0 | 0.64 |
| I can teach sports skills. | 6.0 | 54.9 | 29.1 | 8.6 | 1.5 | 3.6 | 0.79 |
| I can teach gymnastic skills. | 0.9 | 8.0 | 38.7 | 29.9 | 22.5 | 2.4 | 0.94 |
| I can manage fitness activities. | 5.7 | 56.7 | 27.9 | 7.7 | 2.0 | 3.6 | 0.80 |
| I can detect my students' weaknesses. | 5.7 | 59.4 | 28.5 | 5.7 | 0.7 | 3.6 | 0.71 |
| I can correct my students' weaknesses. | 5.4 | 54.7 | 33.6 | 5.4 | 1.0 | 3.6 | 0.72 |
| I need training prior to teaching PE subject. | 22.5 | 43.5 | 19.0 | 12.1 | 2.9 | 3.7 | 1.0 |
| I need PE experience through In-house Training Programme. | 23.7 | 52.6 | 14.2 | 7.7 | 1.7 | 3.9 | 0.91 |

Notes :SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree

Table 2

Teachers' perception on the administration of PE programme

| Statements | | Occurrence in Percentage | | | | М | SD |
|--|------|--------------------------|------|------|------|-----|------|
| | N | RLY | OLY | FLY | AL | _ | |
| Administrators consult teachers before assigning them to teach PE. | 17.9 | 16.1 | 29.7 | 24.7 | 11.5 | 3.0 | 1.3 |
| Administrators presume that PE is essential. | 3.9 | 12.5 | 29.1 | 35.3 | 19.1 | 3.5 | 1.1 |
| Administrators permit PE subjects to be replaced with other subjects. | 33.3 | 23.5 | 28.2 | 11.4 | 3.5 | 2.3 | 1.1 |
| Administrators observe PE teaching | 7.6 | 16.1 | 44.1 | 26.2 | 6.0 | 3.1 | 0.98 |
| Administrators allocate adequate funding for PE facilities | 1.3 | 12.5 | 29.9 | 43.7 | 12.5 | 3.5 | 0.91 |
| Administrators plan In-house Training Programme for PE. | 23.0 | 26.2 | 35.5 | 12.6 | 2.7 | 2.5 | 1.1 |
| Administrators deliberate about factors affecting the teaching and learning of PE with teachers. | 11.5 | 22.3 | 39.3 | 21.3 | 5.6 | 2.9 | 1.1 |

Notes : *N* = *Never*; *RLY* = *Rarely*; *OLY* = *Occasionally*; *FLY* = *Frequently*; *AL* = *Always*

the administrators 'never', 'rarely' and 'occasionally' observed teachers teaching PE.

Independent t-test results showed male teachers agreed more than female teachers that administrators planned in-house training (t(1274)=3.39; p=0.001; Mmale = 2.56,Mfemale = 2.36), They also perceived that administrators discussed PE teaching assignment (t(1274)=3.68; p=0.001, Mmale= 3.09, Mfemale = 2.83), deliberated factors affecting PE teaching (t(1274)=2.57;p=0.01; Mmale = 2.95, Mfemale = 2.80),and observed PE teaching (t(1274)=3.07;p=0.002Mmale = 3.15, Mfemale=2.99). In addition, male teachers reported that administrators permitted PE subjects to be replaced with other subjects (t(1274)=2.10;p=0.036, Mmale = 2.35, Mfemale = 2.22).

PE Class Distribution: Consultation Practice among Administrators

The analyses on five statements in Table 3 revealed that there was a lack of consultation of teachers. Administrators did not discuss PE teaching assignment with teachers (64% responded as 'never', 'rarely' and 'occasionally'). Almost 76% of PE teachers acknowledged that they had no prior knowledge about being assigned PE classes by administrators and that PE classes were assigned to them without basing on PE qualification (71% responded 'never', 'rarely' and 'occasionally') and without considering their interest to teach PE (71% responded as 'never', 'rarely and 'occasionally').

Independent t-test results revealed that male PE teachers agreed that administrators

had discussion with them before assigning them to teach PE, however female counterparts disagreed (t(1273)=2.622, p=0.09, Mmale = 3.01, Mfemale = 2.82). Similarly, male PE teachers agreed that administrators assigned PE class based on their interest as compared to female teachers (t(1274)=8.880, p=0.001, Mmale = 3.03, Mfemale = 2.44). In addition, male teachers (mean=2.97) agreed that PE classes were assigned to them based on their professional qualification as compared to females (mean=2.47) (t(1274)) =7.521, p=0.001, Mmale = 2.97, Mfemale =2.47). Female teachers perceived that administrators assigned PE classes to them without prior notice as compared to male teachers (t(1274)=-2.508, p=0.012, Mmale = 2.48, Mfemale = 2.65). Further, female

teachers felt that they were given PE classes to fulfil their teaching load (t(1274)=-3.863, p=0.001, *M*male = 3.05, *M*female=3.32).

Non-human Factor: The Edequacy of Resources (Facilities, Equipment and Financial Support) to Teach PE

Analyses of the statements in Table 4 showed that almost half of the PE teachers perceived that facilities (52.2%) and equipment (48.1%) for PE were inadequate. Only 42% of PE teachers agreed ('*strongly agreed' and 'agreed*') that financial allocation for PE was adequate. About one third of PE teachers concurred that library PE books were adequate (35.8%), suitable (36.5%) and about 30% of PE teachers perceived that there were ample national language PE reference books in the library.

Table 3

| Class Distribution Practice | | Per | М | SD | | | |
|---|------|------|------|------|------|-----|-----|
| | N | RLY | OLY | FLY | AL | | |
| Class assigned based on consultation with administrators. | 18.9 | 16.0 | 29.4 | 26.1 | 9.6 | 2.9 | 1.2 |
| Class given based on interest. | 21.0 | 21.3 | 28.4 | 21.5 | 7.8 | 2.7 | 1.2 |
| Class given based on Physical Education qualification. | 21.4 | 21.3 | 28.4 | 22.1 | 6.8 | 2.7 | 1.2 |
| Class assigned without teacher's prior knowledge. | 26.3 | 22.5 | 27.6 | 15.8 | 7.8 | 2.6 | 1.2 |
| Class allocated to fulfil teaching workload. | 13.4 | 14.2 | 29.9 | 25.3 | 17.2 | 3.2 | 1.3 |

Notes: N = Never; RLY = Rarely; OLY = Occasionally; FLY = Frequently; AL = Always

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Table 4

Teachers' perception on non-human factors

| Statements | Percentage Agreement | | | | | М | SD |
|--|----------------------|------|------|------|-----|-----|------|
| | SA | A | U | D | SD | | |
| There are sufficient PE facilities in the school. | 4.7 | 47.5 | 22.3 | 23.5 | 2.0 | 3.3 | 0.95 |
| Financial allocation for PE is adequate. | 6.3 | 35.7 | 40.6 | 15.4 | 2.1 | 3.3 | 0.88 |
| Equipment for PE class is adequate. | 4.9 | 43.2 | 22.5 | 27.4 | 2.0 | 3.2 | 0.97 |
| There are ample PE reference books in the school library. | 3.0 | 32.8 | 33.4 | 26.9 | 3.9 | 3.0 | 0.93 |
| PE reference books are suitable. | 2.6 | 33.9 | 40.4 | 20.4 | 2.7 | 3.1 | 0.86 |
| There are ample national language PE reference books in the library. | 2.0 | 27.6 | 39.7 | 26.3 | 4.3 | 3.0 | 0.89 |

Notes:SA = Strongly Agree; A = Agree; U = Undecided; D = Disagree; SD = Strongly Disagree

Independent t-test results showed non-significant differences in all the six statements based on gender.

DISCUSSION

This research examined primary school PE programme in Malaysia. The results of the perception of PE implementation in Malaysia were compared with similar research in other countries for a global perspective.

Teaching Ability and Inadequacy of Specialist PE Teachers

Data analyses disclosed that only 6.2% of the teachers were qualified PE teachers. The shortage of PE teachers was aggravated by non-existence of PE specialist teachers as 71% of the PE teachers had a weekly teaching load of less than 5 periods.

The low percentage of PE majors teaching PE was not in accordance to the policy of MOEM (2016) where it was stated that PE teachers must be qualified in PE or having specialist training in PE. Similar situations were reported in other countries. In a study of the provision of PE in 78 Singapore primary schools, McNeill et al. (2009) revealed that 84% of PE teachers were non-PE specialist with half of the schools having two or less PE specialists. Similarly, Ken (2008) reported 85% of the European countries surveyed employed generalist teachers to teach PE at the elementary level. Salleh and Darmawan (2013) in Malaysia and Weldon (2016) in Australia concurred that out-of-field teaching was common in schools. On the contrary, in Thailand, Amornsriwatanakul et al. (2016) reported that 60% of PE classes were taught by PE specialists.

Numerous Malaysian researchers have reported that even though PE teachers insisted that they could handle their PE students (80% agreed; Wee, 2014), majority of them lacked adequate PE pedagogical knowledge (Chong & Salamuddin, 2010; Noreha & Juslimah, 2009; Wee, 2014), not equipped to teach game skills, and detect and correct student weaknesses (Wee, 2014).

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Consequently, PE teachers avoid teaching artistic and rhythmic gymnastics skills (Chong & Salamuddin, 2010), taught only topics that were familiar and often referred to resources during teaching (Husaina et al., 2015).

On the findings of the superiority of male teachers over female counterparts in having knowledge to teach PE, could manage students and fitness activities, could teach sports skills, can detect and correct students' weaknesses, Wee (2014) found that male teachers perceived their teaching abilities to be higher than that of female teachers in all aspects of teaching abilities found in this study. In another study, Wee and Raj (2010) examined 60 males and 51 females PE teachers in Malaysian secondary schools and found that male teachers were more knowledgeable than female teachers. However, on the contrary, Kovac et al. (2008) surveyed 85 Slovenia PE teachers and reported that female teachers felt significantly more competent than their male counterparts in PE pedagogy, sports pedagogy, classroom management, organizing sport activities and assessment, evaluation and grading. The deficiency in teaching might be the result of the lack of prior professional experience (Alfrey et al., 2012). Primary school teachers felt that they needed to attend PE courses. This is supported by IOM (2013) that when teachers lack training and knowledge, they lack confidence in teaching. Similarly, in New Zealand, Gordon et al. (2013), and Petrie et al. (2013) reported that limited professional development opportunities

had impacted the delivery of PE in primary schools resulting in the lack of professional confidence of classroom teachers to teach PE (Dyson et al., 2016; Powell, 2015). On the contrary, Callcott et al. (2012) believed that generalist teachers had knowledge of students' needs and could provide security and psychological support in primary classroom, thus they were capable of providing developmentally appropriate, best-practice instruction in PE.

Administration of PE Programme

The research results showed that administrators did not consider PE important. Administrators did not often discuss PE teaching assignments, rarely deliberated on factors affecting the teaching and learning of PE with teachers. In addition, they did not plan in-house training programme, did not provide adequate financial support for PE facilities, and rarely observed the teaching of PE.

Chong and Salamuddin (2010) revealed that when exams were approaching, PE classes were used for other subjects such as mathematics and science to enable them to cover the required syllabi. This was previously documented by Wee (2009) that 73.7% of principals 'always' replaced PE classes with other subjects.

Research in other countries have also reported similar findings. In Brazil, 37% of PE teachers faced a lack of recognition in school and 54% had insufficient training (Osborne et al., 2016). Similarly, in Australia Jenkinson and Benson (2010) examined 115 PE teachers and reported that only 3 per cent of respondents reported that PE and sport education were the main priority within their school. Jing (2016) reported that PE teachers frequently expressed discontent about themselves not being seen as legitimate professionals and PE being labelled inferior. In Europe, Griggs (2012) reported that primary school PE had received less attention than secondary schoolPE.

On observation of PE teachers, Wee (2009) reported that only about 51% of principals 'frequently' and always' observed PE lessons, and 6% of them authorized their assistants to carry out their responsibilities. Similarly, PSIR (2007) revealed that only 18.5% of 46 schools performed the mandatory supervision at school level.

On the issue of administrators not taking the initiative to provide training to teachers, Wee (2009) assessed 290 secondary schools and found that only 14% of the principals planned in-house training programmes for unqualified PE teachers.

On the contrary, Strampel et al. (2014) surveyed 36 primary schools and 137 teachers in Ontario, Canada using a 5-point Likert scale revealed that staff and administration perceived that PE/Daily PA as important (mean=3.93), administrators supported PE/Daily PA at school (mean=3.84), and there was supervision on PE/Daily PA (mean=3.22).

PE Class Distribution: Consultation Practise among Administrators

This study revealed that there was a lack of consultation in workload assignment for teaching PE; teachers were assigned to teach PE without considering their interest and qualification. Often, PE classes were given to fulfil total teaching loads.

In Malaysia, Wee (2014) reported that only 28.4% of PE teachers agreed that they were frequently and always consulted by administrators before being assigned PE classes. About 9% of them perceived that they were given PE classes due to their interest. Almost 68% ('never' and 'rarely') of PE teachers emphasized that their assignment was given without considering their qualification. About half of the sample (46.3%) reported that they had no knowledge of PE teaching assignment. In fact, only 18.6% (responses as 'frequently' and 'always') of the respondents agreed that PE classes were given to teachers in order to fulfil the number of teaching periods required. In Brazil, PE assignment was given without teachers' knowledge because PE was treated as a marginalized subject in schools (Osborne et al., 2016).

Globally, the use of unqualified teachers to teach PE was not uncommon. In Singapore, McNeill et al. (2009) reported that 50% of the 78 schools surveyed had two or less PE specialists. In Australia, Lynch and Soukup (2017) revealed that 81% of principles/head teachers confirmed that classroom teachers were often solely responsible for the implementation of Health and PE in public schools. Similar situation existed in primary school in Ghana (Sofo & Asola, 2016).

Jenkinson and Benson (2010) examined teaching priority in Australian primary schools and found only 3% of respondents perceived PE as the main priority within their school. Strampel et al. (2014) surveyed 36 primary schools and 137 teachers in Ontario, Canada and found that PE was not a high priority subjects as compared to other academic subjects.

Non-human Factor: The Adequacy of Resources (Facilities, Equipment and Financial Support) to teach PE

The results of this study showed teachers perceived books, equipment, facilities and financial allocation for PE were inadequate.

In Malaysia, Syed Ali et al. (2014) examined non-human factors in 155 primary schools involving 310 PE teachers. Seventyseven percent of the teachers acknowledged shortage of PE equipment in their schools while 86% reported that damage equipment was unrestored or not replaced. These might be due to insufficient funding for PE (79% agreed) which was exacerbated by inappropriate usage of PE budget (81% agreed). They also revealed that outdoor facilities were narrow (83% agreed) and crowded (85% agreed).

Similar situation was reported by McNeill et al. (2009) in Singapore where 58% of PE teachers felt that PE facilities were inadequate. This is supported by Strampel et al. (2014) in Canada where outdoor and indoor facilities were not only inadequate but indoor facilities were often used for other events. Similarly, indoor gym for PE classes was used as a resource room or study room for other subjects (Kougioumtzis et al., 2011). The situations were clearly inferior when compared with European schools where around two-thirds of the countries surveyed indicated the quality of facilities for teaching PE to be adequate to excellent (Ken, 2008).

CONCLUSION

This study shows that majority of the PE teachers perceived themselves to be able to manage their class, could teach sport skills as well as detect and correct students' weaknesses. However, almost half of the surveyed subjects acknowledged that they lacked PE pedagogical knowledge especially in the teaching of gymnastics. Male teachers perceived they were better than female teachers in those abovementioned aspects except the teaching of gymnastics. Both male and female teachers echoed the need to attend PE courses and get exposure through in-house courses. The results suggest that specialist PE teachers are very much needed. Thus, leadership role and attitude toward PE of school administrators are important. However, the results of this study revealed that only about half of the administrators assumed PE to be important in the school curriculum. Majority of the administrators assigned teachers to teach PE without consultation, let alone taking into consideration teachers' interest and qualification. Administrators rarely had discussion on factors affecting teaching and learning of PE. In addition, they did not observe PE teaching and plan in-house training as required by the MOEM. They also did not provide adequate financial support for PE facilities as well. On nonhuman factors, PE teachers perceived that financial allocation was inadequate leading to insufficient facilities, equipment and reference books. To overcome the abovementioned issues, numerous proposals could be implemented by MOEM such as to conduct more PE in-house training programme and special courses to upskill non-PE majors and to enhance the performance of teachers who performed unsatisfactorily. While the implementation of PE at the school level depends on the vision of the school administrators, it is important that various stakeholders work together to advocate for quality PE programmes for all students in Malaysia.

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Examining Public Acceptance towards Physical Activity Involvement of People with Disabilities (PWD) – A SEM Approach

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ABSTRACT

Social acceptance by people without disabilities has been identified as one of the prominent obstacles faced by people with disabilities (PWD) in their involvement in physical activity. To further apprehend this issue, the present study aims to examine the factors that influence public acceptance towards PWD involvement in physical activity. An exploratory model of public acceptance was developed using key antecedents identified from previous literature. Using convenience sampling technique, a total of 444 responses were collected from the public (without disabilities), who were exercising at four urban public recreation parks located in Klang Valley. Structural Equation Modeling (SEM) approach was used to analyze the data collected. The findings revealed the importance of five prominent antecedents that were personality, attitudes, exposure, ethnicity and subjective

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E-mail addresses: ongtf@tarc.edu.my (Ong Tah Fatt) senoritaaida87@gmail.com (Aida Roha Abdul Rashid) *Corresponding author norms in explaining public acceptance towards physical activity participation of the disabled. Subjective norms were identified as the most important factor in influencing public acceptance. Additionally, public attitude also depicted a mediating role in the relationship between exposure and public acceptance. A pertinent contribution of the study was the introduction of the extended model of public acceptance developed from integrated framework of theory of reasoned action (TRA), social learning theory, and big five model (BFM), which

ISSN: 0128-7702 e-ISSN: 2231-8534 contributed better understanding of public acceptance towards disabled people. Further understanding of these factors towards PWD involvement in physical activity is essential to promote social inclusion in building a better community for the PWD. Implications of the result for future practices and directions of research are discussed.

Keywords: Attitude, people with disabilities, public acceptance

INTRODUCTION

It is well documented that regular involvement in physical activity offers physical and psychological benefits, encourage personal development, promotes social interaction and quality of life among people with disabilities (Manus et al., 2008). However, these benefits cannot be realized if the involvement/participation of people with disabilities in physical and recreation activities are low. Individuals with disabilities are reported to face with various types of barriers, such as stigma perception, family support, social environment condition and physical condition that influence their involvement in physical and recreation activities (Rimmer et al., 2004). As observed by Human Rights Commission of Malaysia, inequalities in different aspects of life faced by people with disabilities (PWD) in Malaysia have negatively affected their access to education, employment and health, resulting in their being marginalized from social participation in the community (Babulal, 2017). This may have been the result of negative attitude, stigma, social

alienation that forms a barrier to PWD's active participation in the community, which includes participation in physical activity. As emphasized in Maslow's hierarchy of needs, to be accepted by other people in the community (belongingness) is one of the basic human needs. Thus, social acceptances by the community towards physical activity participation of PWD play a vital role in motivating them to increase their involvement in sport and recreational activities.

Literature Review

Based on theory of reasoned action (TRA), people's intention or motivation is the main determinant of their behaviour. Intention is influenced by two factors: personal attitudes, which are the individuals' beliefs about outcome of the target behaviour and subjective norms, which are the individuals' beliefs about the outcome of the target behaviour based on other's (i.e. parent, families, friends, spouse) perception or opinion (Fen & Sabaruddin, 2008). In the TRA assumption, public will involve in physical activity together (behaviour) with PWD when they can accept them positively (attitude) and people around them support their decision to engage in it (subjective norms) (Downs & Hausenblas, 2005).

Acceptance

Public acceptance is defined as a willingness to recognize, live near, or be associated with a certain group of individuals (Helene et al., 2010). Acceptance, in the form of behavior, is largely influenced by attitude. Verdugo et al. (2012) noted that positive attitude could herald greater acceptance of inclusion and might have a direct impact on the quality of life for PWD. Whereas, negative attitudes that linked to behaviours such as non-acceptance (social rejection) could results in higher levels of social distance toward PWD (White et al., 2006). Nowicki (2006) had highlighted that, the full rightful acceptance of people with disabilities was unlikely to be fulfilled, as long as negative attitudes persisted. Thus, positive attitudes and sufficient knowledge about the special needs of PWD among public can have a significant impact on the social acceptance of PWD in the community.

Attitude

Personal attitude may be describes as a belief and opinions held by an individual about referent object. Attitudes consist of three components which are, affective (feelings/ emotions), cognitive (beliefs/knowledge) and behavior, all being generated by the attitudes object (Perry et al., 2008). The values of the attitude components, as well as their relative weight in predicting public acceptance, vary from person to person depending on a variety of cultural, individual and social factors. Behaviour is related to attitudes in complex ways. Numerous studies have found that differences in the extent to which attitudes guide behaviour are the consequences of difference factors such as habit or past behaviour (Triandis, 1977), volitional control of behaviour (Davidson & Jaccard, 1979), and the degree of direct experience with the attitude

object (Zimbardo, 1985). Understanding these differences has important theoretical and implications for our understanding of the social influence process. It is well documented that negative public attitudes foster low expectations, discriminatory behaviors, and marginalization of PWD, whereas positive attitudes lead to acceptance of PWD and promote integration into society (World Health Organization, 2011). Hutzler (2003) added that attitudes toward participation of individuals with disability could possibly be a mediating variable constructing the behavior of public such as the professionals managing, teaching, and coaching the activities; and family members, peers without a disability; and important others within a physical activity context.

Subjective Norms

Subjective norms refer to the individual's perception of social pressure in performing or not performing a given behaviour, or actions and it is determined by normative beliefs which assess the social pressure on the individual about a particular behaviour (Yap & Noor, 2008). Walker and Scior (2013) studied the association of social support between PWD and people without disabilities and reported that low level of social supports from family, or friends, for individual without disabilities would decrease their involvement together with PWD in the future relationship. Saaty et al. (2015) supported the notion that strong social supports from parents, family members, friends, spouse or society played an important role in increasing acceptance

of PWD in the community. Thus, subjective norms may have a bearing on individual's behavioral intention to accept PWD's involvement in physical activity.

Exposure

The 'contact' hypothesis (Allport, 1955) suggests that greater exposure to stigmatized group will bring about changes in attitudes - both positive and negative (Ferrara et al., 2015). Findings from a number of studies supported the association between contact and attitudes, and found that contact in various forms (e.g. voluntary, intimate, direct, and indirect) can help to improve prejudiced attitudes (Corrigan et al., 2001). Previous exposure to disability such as with friends or family members can positively affect the attitudes of children without disabilities towards their peers with disabilities (Block & Obrusnikova, 2007). Krahe and Altwasser (2006), emphasized that exposure to PWD was an important actor that helped to improve the attitudes of non-disabled people This idea of exposure and the contact hypothesis are the major concepts behind inclusion. However, studies have also shown that exposure alone will not change attitudes in a positive direction (Siperstein et al., 2007). To successfully change attitudes, quality well-planned and structured contact is critical. A shift to a more positive attitude has been shown to herald greater acceptance of inclusion and hence may have a direct impact on the quality of life for PWD (Verdugo et al., 2012).

Ethnicity

Ethnicity is considered one of the important elements of cultural phenomenon which influences on person's attitude (Kamaruddin, 2007). People who stay together as a community in the same place or area basically share the same culture. According to the culture values theory by Schwartz (1999), cultural values represent the implicitly and explicitly shared abstracts ideas about what is desirable, good, need and right in the community (such as religion, custom, social relationship, foods and language). Several studies (Goreczny et al., 2011; Sheng & Gao, 2012), had indicated that, significant correlation between ethnicity and level of acceptance towards PWD exists among publics, though some researchers found otherwise (Lua & Neni, 2011). Hence, there is a discrepancy regarding the relationship between ethnicity and public's acceptance, which need to be elucidated.

Personality

Personality is defined as an individual's characteristics patterns of behaviour, thought and emotion, together with the psychological mechanisms hidden or not behind those patterns (Funder, 1997). This definition describes the motivational control that influences a person's behaviour (Barrick et al., 2013). Several studies supported that, there are five primary factors of personality (i.e. extraversion, conscientiousness, neuroticism, intellect and agreeableness), known as the Big Five Model (BFM) (Goldberg, 1990). Evidence from psychology literature showed that

personality positively influenced public behaviour towards PWD in various physical activity studies (Hausenblas & Giacobbi, 2004; Tolea et al., 2012). However, literature in examining the relationship between personality traits and acceptance among public towards PWD's involvement in physical activity is almost non-existence with the exception of Wilson and Dishman (2015) and Page and Islam (2015). It was found that higher levels of the personality dimensions in openness and agreeableness had a significant but relatively weak association with positive attitudes towards Person with Intellectual Disability. With the purpose to ascertain its role in influencing level of public's acceptance towards PWD, personality traits had been considered as one of the antecedents in influencing behavioural intention of public in this study (Page and Islam, 2015).

Problem Statement

Previous studies in Malaysia concerning PWD have been mainly focusing on the physical environmental factors i.e. inaccessibility issue of built environment such as transportation, and variety of public building (Rahim & Samad, 2010; Soltani et al., 2012). Apparently, there is a lack of research to examine the issue of physical activity participation among PWD from the socio-psychological perspective, which involved attitude and social acceptance factor. A review of literature showed that past studies on PWD involvement in physical activity had been emphasizing on factors such as previous experience, knowledge, cultural background, subjective norms and attitude (Blue, 1995; Rimmer et al., 2004). Researchers have stressed that more future studies should focused on other prominent factors that have strong association with involvement or non-involvement in physical activity among PWD (Perry et al., 2008; Rimmer et al., 2004; Werner & Grayzman, 2011). Identifying the gap in the body of knowledge, the current study extended the scope of research by addressing two new factors: the Big Five Model (BFM) of personality traits and ethnicity in explaining the phenomenon. Thus, this exploratory investigation aims to examine the internal factors (attitude, personality) and external factors (exposure, ethnicity, subjective norm) that influence public acceptance towards PWD involvement in physical activity. The study also aims to identify the mediating role of attitude in the relationship between external factors (exposure and ethnicity) and public acceptance towards PWD involvement in physical activity. The conceptual framework of the present study is as shown in Figure 1.

MATERIAL AND METHODS

Participants

Four urban public recreation parks were randomly chosen (using fishbowl method) from nine parks that were located in Klang Valley. The parks should fulfill the criteria that their location and facilities are easily accessible, and user friendly to PWD. The



Figure 1. The research framework

selected public recreation parks were Taman Tasik Titiwangsa Kuala Lumpur, Wetland Putrajaya, Taman Tasik Shah Alam and Taman Subang Ria, Subang Jaya.

Based on the sample size determination table by Krejcie and Morgan (1970), a sample size of 384 respondents was deemed to be adequate for the population of 3,350,000 adults in Klang Valley. Taking into consideration of possible missing data, additional 20% (76) of sample were considered. Thus, a total of 460 questionnaires were distributed, with 444 being collected. Convenience sampling technique was utilized in the data collection process, whereby self-administered questionnaires were distributed to the public during their resting time after performing physical activity at the Recreation Parks.

Instrumentation

The survey instrument was a structured close-ended questionnaire consisting of three sections. The first section comprised 6 items about demographic profiles (gender, marital status, age, race, education level and occupation). The second section consisted of 52 items concerning five independent variables namely, personality (20 items), exposure (6 items), ethnicity (5 items) subjective norms (4 items), and attitude (17 items). The third section comprised 6 items measuring intention to accept people with disabilities involvement in physical activity.

The instrument measuring personality was adopted from the Mini-International Personality Item Pool (IPIP) Scale of the Big Five Model (BFM), which measured the five dimensions of Extraversion, Agreeableness, Conscientiousness, Neuroticism and Intellect (Donellan et al., 2006). The Acculturation Scale for Vietnamese Adolescents (Nguyen & Von Eye, 2002) was used to measure the culture variables of ethnicity. Measure for subjective norm was adapted from the Theory of Planned Behaviour questionnaire by Werner and Grayzman (2011). Attitude was measured using questionnaire adapted from the Multidimensional Attitute Scale towards Person with Disabilities by Findler et al. (2007). All the above variables were measured using 7-point Likert scale. Questionnaire on exposure was adapted from study by Toran (2010). The instrument measuring public acceptance was adapted from the Children's Attitude towards
Inclusion in Physical Education Revised Questionnaire (CAIPE-R) by Bebetsos et al. (2013).

A pilot study involving 46 respondents was conducted to examine the reliability and validity of the questionnaire, through Cronbach's alpha values and item-to-total correlation. According to Pallant (2000), reliability value (Cronbach's alpha) of 0.60 to 0.70 are considered as acceptable, and value above 0.80 is preferable The Cronbach's alpha reliability values for the variables were: exposure ($\alpha = 0.75$), ethnicity ($\alpha = 0.76$), subjective norms ($\alpha =$ 0.82), influencing individuals ($\alpha = 0.77$), personality ($\alpha = 0.71$) and public acceptance $(\alpha = 0.91)$. Basically, all the measures for the variables have achieved an adequate level of reliability.

Statistical Package of Social Science (SPSS) program version 20.0 and Analysis of Moment Structure (AMOS) were employed to analyze the data in this study. Exploratory factor analysis (EFA) was performed on the multi-dimensional construct of attitude, based on 17 items in the pilot study. EFA analysis revealed the presence of three components (affective, cognitive, and behavioral) with eigenvalues exceeding 1.0, explaining 56.28% of the variance respectively. The reliability for the attitude construct was, α =0.704, confirming that the measurement tool has attained an acceptable level of reliability.

All final collected data were checked to ascertain whether the multivariate assumptions were fulfilled before analysis. The existence of normality, outlier, linearity, homoscedasticity and multi-collinearity were further examined. Confirmatory factor analysis (CFA) was applied to ensure that measurement model of the constructs was valid in the current study. SEM was used to test the conceptual model that examined the antecedents of public acceptance.

RESULTS

In terms of demographic profile of respondents, there were slightly more female (55.4%) respondents than the males (44.6%). About two-third (62.6%) of the respondents were single. Majority of the respondents were young adults, aged between 20 and 29 years old (65.8%). In relation to ethnic groups, most respondent were Malays (51.1%), followed by Chinese (35.8%) and Indians (13.1%). Respondents with academic qualification of diploma or higher form the majority of the respondents were government servants (21.2%), students (20.9%) and individuals from business sectors (19.6%).

A confirmatory factor analysis (CFA) of the measurement model was tested, with all constructs allowed to be inter-correlated freely. According to Anderson and Gerbing (1988), confirmatory measurement models should be evaluated and re-specified before proceeding to the examination of the structural equation model. The proposed model was assessed employing multiple fit criteria that comprised the Chi-square statistics (χ 2), p-value of the statistics, degree of freedom (df), relative Chi-square (χ 2/df), comparative fit index (CFI), the root mean square error of approximation

(RMSEA) and the Tucker-Lewis Index (TLI). As $\chi 2$ statistic is very sensitive to larger sample size (exceeds 200), it is no longer relied upon as a basis for acceptance or rejection of model (Schermelleh-Engel et al., 2003; Vandenberg, 2006). Hence, the use of multiple fit indexes (such as RMSEA, CFI, TLI) had been included to provide a more holistic view of the goodness of fit (GOF). The recommended threshold for each fit indices were: $\chi 2/df < 5.0$ (Wheaton et al., 1977); p value < 0.05; CFI > 0.95 (Hu & Bentler, 1999); RMSEA <0.08 (MacCallum et al., 1996) and TLI >0.95 (Hu & Bentler, 1999).

Fit indices for the measurement model are shown in Table 1. Since the chi-square p-value is significant, the bootstrap method is employed as this is a non-parametric resampling test that can be applied when the assumptions of large sample size and multivariate normality may not hold (Preacher & Hayes, 2004). Bootstrap procedure has the ability to generate accurate estimates of the standard error of correlation coefficients and allows researchers to assess the stability of parameter estimates (Switzer et al., 1992). The value $\chi 2/df$ in the proposed model was 1.78, which falls below the suggested value, indicating it has achieved a good fit model. The CFI value of 0.97 and TLI value of 0.96 also supported a good fit to the model. The RMSEA value for the proposed model was 0.045, which means only 4.5% of the variances were left unexplained. The multiple fit indices for the proposed model were χ 2=727.79, df=411, χ 2/df=1.78, CFI=0.97, RMSEA=0.045 and TLI=0.96. Apparently, this was a good fit model for the sample data, with all fit statistics well established, satisfying the threshold values.

Structural Model

To test the hypothesized relations between the independent constructs and dependent constructs, a structural equation model was estimated. Acceptance was hypothesized to be functions of personality, exposure, ethnicity, attitude and subjective norm. Meanwhile, a direct path from exposure and ethnicity to attitude was also estimated to the mediation hypotheses. Figure 2 showed the path diagram of structural model that was proposed for the current study based on the SEM analysis. Since all the fit indices meet the cut-off values, it can be concluded that the fit of the proposed model was reasonably good (Table 2).

Table 1Fit indices for measurement model

| 5 | | | | | | | |
|----------------------|--------|-----|----------|---------|------|-------|------|
| Constructs | χ2 | df | P < 0.05 | (χ2/df) | CFI | RMSEA | TLI |
| Measurement Model | 727.79 | 411 | 0.000 | 1.78 | 0.97 | 0.045 | 0.96 |

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| Constructs | χ2 | df | P < 0.05 | (χ2/df) | CFI | RMSEA | TLI |
|---------------------|--------|-----|----------|---------|------|-------|------|
| Structural Model | 765.75 | 413 | 0.000 | 1.85 | 0.96 | 0.047 | 0.95 |

The correlations among the variables are shown in the path analysis result in Table 3. Based on the results of the correlation coefficient value, subjective norm (β =0.35, p < 0.01), attitude ($\beta = 0.32$, p < 0.01) and exposure (β =0.15, p<0.05) were found to have direct significant relationship with public acceptance, but not personality $(\beta = -0.04, p = 0.56 > 0.05)$ and ethnicity $(\beta=0.09, p=0.28>0.05)$. However, the path analysis indicated that both ethnicity $(\beta = -0.38, p < 0.01)$ and exposure $(\beta = -0.51, p < 0.01)$ p<0.01) had significant relationship with the attitude construct. The Sobel test was applied to examine whether a mediator variable (attitude) significantly carried the

influence of independent variables (ethnicity and exposure) towards dependent variable (public acceptance). The result indicated that attitude acted as a partial mediator in the relationship between exposure and public acceptance. Using Sobel test, the magnitude of indirect coefficient value was 0.16. The indirect effect of EXP \rightarrow ATT \rightarrow ACC, was found to be significant (p<0.01) with Sobel statistic value 2.68. In the case of ETH \rightarrow ATT \rightarrow ACC, the mediation effect of attitude could not be established, as the relationship between ethnicity and public acceptance is not significant.

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|--|--------------------|------|------|------|----------------------|-----------------------|-----------------------------|
| Observed relationship | Direct path (β) | S.E | C.R | Р | Indirect path (β) | Sobel Test statistics | Probability (two-tailed) |
| $PSN \rightarrow ACC$ | -0.04 | 0.23 | 0.59 | 0.56 | | | |
| $\mathrm{EXP} \to \mathrm{ACC}$ | 0.15 | 0.14 | 2.0 | * | | | |
| $\mathrm{ETH} \to \mathrm{ACC}$ | 0.09 | 0.08 | 1.1 | 0.28 | | | |
| $\text{ATT} \to \text{ACC}$ | 0.32 | 0.16 | 3.1 | ** | | | |
| $SN \rightarrow ACC$ | 0.35 | 0.07 | 5.5 | ** | | | |
| $\mathrm{ETH} \to \mathrm{ATT}$ | 0.38 | 0.05 | 4.6 | ** | | | |
| $\mathrm{EXP} \to \mathrm{ATT}$ | 0.51 | 0.08 | 5.2 | ** | | | |
| $\begin{array}{l} \text{EXP} \rightarrow \text{ATT} \rightarrow \\ \text{ACC} \end{array}$ | | | | | 0.16 | 2.68 | ** |
| ETH → ATT→ACC | | | | | 0.03 | 2.60 | ** |

Coefficient value, Standard Error and mediation effects of attitude

*p<0.05, **p<0.010

Table 3

DISCUSSION

Among the three independent variables (subjective norm, attitude and exposure), subjective norm was found to has the strongest direct significant relationship with public acceptance, This finding is consistent with the study of Dan et al. (2011), in which social influence and support from family and peers were associated with greater involvement in physical activity and increased the level of acceptance towards PWD. Clemente (2017) too agreed that family social support was the stronger predictor to influence someone decision to accept people with disabilities either in physical activity or in their socialization life. The significant correlation between attitude and public acceptance in the current study supports many previous findings in the physical activity domain (Blanchard et al., 2008; Perry et al., 2008) in which attitudes will guide behavior. Positive attitude will be appearing when we feel and have belief towards person, objects or situation in a good way. When a person attaches the desire to behave or act in a certain way based on the positive emotions, he develops positive opinion and reacts in positive response towards the situation, person or object (Perry et al., 2008). The results supported the predictions made by the theory of reasoned action, whereby public acceptance behavior is influence by subjective norms and attitude towards disability. The significant relationship of the findings in the present study provide noteworthy evidence that the theory of reasoned action(TRA) is a robust theory, and could provide a good theoretical foundation to form effective model in examining public acceptance of PWD involvement in physical activity.

As for exposure and public acceptance, the result is consistent with several findings in physical activity studies, whereby the level of exposure directly influence public acceptance (Ferrara et al., 2015; Li & Wu, 2012). This is to say that having more previous experience with PWD, results in more acceptance toward them, even though in different environment such as at workplace (Daruwalla & Darcy, 2005; McDonnall et al., 2015) and at school (Brown et al., 2009). Therefore, what this result suggests would be that the more intensive and regular contact that the public have with people with disabilities, the more positively they may feel about PWD, and this will subsequently enhance public acceptance.

The direct correlations between two variables (personality and ethnicity) and public acceptance were weak and not significant. The current study revealed that, as a general construct, personality did not influence on public acceptance towards PWD involvement in physical activity. However, three of the sub-dimensions of individual personality traits i.e. agreeableness, intellect and conscientiousness, were identified as dominant characteristic of the public which could influence their acceptance level towards PWD involvement in physical activity. As there was no previous study to explore the relationship of personality and public acceptance in the context of public acceptance towards PWD involvement in physical activity, the present study presented distinct contribution in the area of physical activity studies.

The direct influence of ethnicity on public acceptance was found not significant. This finding is consistent with the study by Kaur et al. (2015), whereby there is no difference in public acceptance among the three ethnic groups in Malaysia as perceived by respondents who are PWDs. Although Malaysia is a multicultural country that consist of diversity ethnic backgrounds that practices different languages, the citizens uphold the same cultural values that is to be kind, sympathy, tolerance and helpful in their daily life practices. Due to the process of acculturation, whereby people have been living together in one place for a long time (country/state) as a community and has experienced assimilation. This practice has enable them to live together in a harmony community. Hence, this explains the non-significant direct influence of ethnicity on public acceptance towards PWD involvement among Malaysians.

The current study revealed that attitude acted as partial mediator in the relationship between exposure and public acceptance. The finding is consistent with study by Michele et al. (2015), which found that public that had greater knowledge, frequently exposed to and having contacts with PWD tended to have positive attitude towards them. Hence, it increases their acceptance towards this special population (PWD) in society. The finding revealed that exposure in the form of intervention programmes, training, inclusion activities or media coverage, would act as an attitudeshaping mechanism, which could assist in the development of public acceptance towards disabled participation in physical activity.

Recommendation and Direction for Future Research

It is recommended that future study should be extended to other geographical areas such as rural public parks, so as to obtain better generalized result. For future study, detailed research using triangulation method, involving other qualitative techniques, may be used to get a better understanding on the public acceptance issue. Future study can include assessment of different variables/factors and their moderation/ mediation effects, which was not examined in the present study. This would help to accomplish a comprehensive assessment of public acceptance towards PWD, as well as provide future directions for other researcher.

CONCLUSION

This study demonstrated the existence of causal relationship between personality, exposure, ethnicity, attitude and subjective norms with public acceptance towards PWD involvement in physical activity using SEM. The strong influence of both subjective norms and attitude on public acceptance highlighted the critical roles of public in influencing PWD's physical activity participation in their daily life. Thus, it is imperative for the related governmental or non-governmental agencies (e.g. Social and Welfare Department of Malaysia and Malaysia Paralympic Council) to introduce different approaches of promoting inclusive physical activity program (such as Sports for disabled Week) that creates awareness and exposure for the public to be mindful of the needs of the PWD. Efforts in disseminating more information concerning PWD's physical activity participation would be enhanced using electronic mass communication media including social media. Live telecast/broadcasting of para sports events through different types of media could bring more awareness and cultivate positive attitude influencing public acceptance level towards PWD. It is also essential for recreational park authorities to provide more accessible and disabledfriendly environment that stimulate contacts between PWD and the community/public.

Success in molding the acceptance of public towards PWD requires a collective effort of various stakeholders which include public without disabilities, government agencies, policy makers, responsible organization and recreational practitioners. In conclusion, the results of present study offered support to consider the suggested variables of subjective norms, attitude, exposure, personality, and ethnicity as antecedents that affect public acceptance towards PWD involvement in physical activity.

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Effect of Fluid Balance on Thermoregulatory Responses in Obese Individuals during Exercise in the Heat

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ABSTRACT

Hot and humid weather in Malaysia seems to discourage obese individuals from exercise in the outdoor. The purpose of this study was to examine the effect of fluid balance on thermoregulatory responses in obese individuals during exercise in hot condition. A total of 10 obese $(23.0 \pm 5.2 \text{ years}; 92.2 \pm 9.2 \text{ kg}; \text{BMI}: 32\pm 2.5 \text{ m}^2/\text{kg}; 32.4 \pm 2.6\% \text{ BF})$ and 10 normal weight individuals $(21.0 \pm 1.8 \text{ years}; 65.6 \pm 4.2 \text{ kg}; \text{BMI}: 23.0 \pm 1.2 \text{ m}^2/\text{kg}; 11.1 \pm$ 1.1% BF) were recruited for this study. Subjects underwent 50 min of cycling at 50% VO_{2max} under 4 conditions: (i) euhydrated in thermoneutral condition (24.5°C; 53.8 rh) (EUT), (ii) hypohydrated in thermoneutral condition (HYT), (iii) euhydrated in hot condition (34.7°C; 54% rh) (EUH) and (iv) hypohydrated in hot condition (HYH). Subjects were instructed not to ingest fluid for 8 hours prior to the hypohydrated condition trials. No significance difference was found between obese and normal weight groups in heart rate (HR), VO₂,

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ISSN: 0128-7702 e-ISSN: 2231-8534 core temperature (T_{core}), skin temperature (T_{sk}) in all the 4 trials. Sweat loss in the normal weight group was greater than the obese group (1.21% vs. 0.75% Δ BW; 1.70% vs. 0.99% Δ BW) in EUT and EUH trials (p=0.035; p=0.017, respectively). HR in EUH trials were significantly higher than EUT trials at 10 min in the normal weight group and at 20 min of exercise in the obese group (p<0.05). HR in HYH trials were significantly higher than HYT trials at 0 min in the normal weight group and at 10 min the normal weight group group (p<0.05). With ~ 1% of

BW loss prior to exercise, obese individuals have similar physiological responses as normal weight individuals when exercising in the heat (35° C; 64% rh) for 50min at 50% VO_{2max} of cycling.

Keywords: Euhydrated, heat, heart rate, hypohydrated, sweat rate, obese

INTRODUCTION

According to World Health Organization (WHO) (2017), more than 650 million out of 1.9 billion adults (13% of the world population) in the world are obese. "The Economist Intelligence Unit" (2017), which covered Malaysia, Singapore, Indonesia, Thailand, Philippines and Vietnam also mentioned that Malaysia was the most obese in the region with the highest obesity and overweight prevalence sample in the country (13.3% and 38.5% respectively). It is estimated that 45.3% of Malaysian population are obese ("Malaysia's obesity", 2014). Also according to Ministry of Health Malaysia (IPH, 2015) the obese patient are often related to diseases such as hypertension and diabetes.

Exercise is well known as an excellent therapeutic intervention for controlling obesity (Chan & Woo, 2010; DiPietro et al., 2013; Foster-Schubert et al., 2012). A minimum of 150 min per week of moderate intensity physical activity was recommended by American College of Sports Medicine (ACSM) guideline for the overweight and obese individuals (ACSM, 2013). Although the recommendation has been made but the obesity rate in the Malaysia does not seem to be changing over the recent years. This may be due to the process of urbanization, wealth increase and changes in industrial work nature causing a decrease in physical activity level in Malaysia population (Davey et al., 2013).

Malaysia is a country with tropical climate which its temperature and humidity $(\sim 32^\circ, 70\%$ rh) can be relatively constant throughout the year. Most people tend to stay and work in the thermoneutral zone around 23°C as they perceive as a comfortable ambient temperature which greatly reduce the desire to go for outdoor activities (Yang et al., 2015). Therefore, ambient temperature in Malaysia could be one of the factors which discouraged people to exercise at outdoor, especially in obese individuals. An obese individual possesses additional insulation provided by layers of adiposity, potentially disadvantageous during heat stress conditions and more susceptible to heat injury (Chung & Pin, 1996). When the ambient temperature rises above the upper thermoneutral zone limit, physiologic processes to amplify heat dissipation are activated resulting an increase in metabolic rate. In an obese individual, exposures to ambient temperature above the thermoneutral zone would also increase metabolism as processes are activated to increase heat dissipation against a smaller thermal gradient (Frank et al., 1986). In addition, overweight and obese individuals have higher metabolic rate, heart rate and core temperature than normal weight individuals (Bar-Or et al., 1969), which may cause thermoregulatory and circulatory strain during exercise in the heat.

Hydration level of an individual can determine the efficiency of the body to maintain optimal thermoregulation. Hypohydration condition may cause extra stress on the body as the intracellular and extracellular volume decreased (Sawka et al., 2001). Human body starts sweating under hot condition to dissipate excessive heat generated in the body in order to maintain an optimal T_{core} (~37°C) (Boone, 2014). But with the average ambient temperature in Malaysia being approximately ~32-35°C and with the daily exposure to the outdoor hot conditions it may induce certain level of acclimation effects on people living inside the country. Obese individuals may be more at risk for heat-related illness and less efficient at the thermoregulatory responses due to lower sweat rate and lower thermal sensation as compared to non-obese individuals (Kanikowska et al., 2013). However, the heat tolerance threshold with hypohydrated conditions in obese individuals is not well documented.

To our knowledge, studies of thermoregulatory function and fluid balance in overweight and obese are limited. The extent to which hypohydration increases thermoregulatory and circulatory strain in obese individuals is not clear. It is essential to evaluate the amount of heatinduced physiological strain in obese individual can tolerate during exercise in hot conditions. Therefore, the purpose of this study was to examine the effects of fluid balance on thermoregulatory responses in obese individuals during exercise in the heat. Understanding the heatinduced physiological strain and different hydration levels which can be tolerated by the obese individuals are important, as the findings of this study could add into the exercise guideline and precaution for obese individuals when exercising in the heat.

METHOD

Subjects

A total of 10 obese $(23.0 \pm 5.2 \text{ years}; 92.2 \pm 9.2 \text{ kg}; \text{BMI: } 32\pm 2.5 \text{ m}^2/\text{kg}; 32.4 \pm 2.6 \ \%\text{BF}$) and 10 normal weight individuals $(21.0 \pm 1.8 \text{ years}; 65.6 \pm 4.2 \text{ kg}; \text{BMI: } 23.0 \pm 1.2 \text{ m}^2/\text{kg}; 11.1 \pm 1.1\% \text{ BF}$) were recruited for this study. An individual with a body fat ranged from 30% or more and a body mass index (BMI) of 30 kg.m⁻² and above was classified as obese, whereas the normal weight individual has a body fat ranged from 10%-22% and BMI of 24 kg.m⁻² (ACSM, 2013).

Experimental Design

Subjects undertook 1 preliminary testing and 4 experimental trials in randomized order. The preliminary testing included anthropometric measurements, submaximal and maximal oxygen consumption (VO_{2max}) tests (Modified Astrand Cycling Protocol to determine the VO_{2max} and maximal heart rate (HR_{max}) during exercise in order to prescribe the intensity of exercise for the subsequent 4 experimental trials. For submaximal test, subjects underwent at least 4 stages of cycling on cycle ergometer (Corival, Lode, Netherlands) with gradually

increased intensity of 30 W at every stage. Subjects were required to cycle for 4 min and maintain the pedal cadence between 60-70 rpm for each stage. After all stages were completed, subjects were provided with a 5 min recovery time and then followed by an incremental load of 30 W every 2 min until exhaustion. Subjects were instructed to maintain a pedal cadence between 80 to 100 rpm during exercise and to exercise to volitional fatigue. The test was terminated when the subject could not maintain a pedal cadence of 60 rpm. Rating Perceived Exertion (RPE) (Borg, 1998) was recorded at every stage. VO2 and HR were constantly recorded using metabolic cart (K4B2, COSMED, Italy) and heart rate monitor (Polar, FT4, Finland).

The experimental trials included cycle ergometer exercise under four different environmental conditions: (1) Euhydrated hot condition (EUH), (2) Hypohydrated hot condition (HYH) [humidity fixed at 70%] and (3) Euhydrated thermoneutral condition (EUT), (4) Hypohydrated thermoneutral condition (HYT) [humidity fixed at 30-40%]. Each experimental trial consisted of 50 min of cycling on a cycle ergometer at 50% VO_{2max} per session. Subjects were instructed to cycle on the ergometer for 5 min at 60 rpm as a warm up before the trial and another 5 min after the trial to cool down their body. Each experimental trial was separated for at least 3 days apart. Hydration status of the subjects was determined using urine specific gravity (USG) and changes in body weight.

Subjects were instructed to avoid the ingestion of alcohol, caffeine, any drugs and tobacco, strenuous physical activity 24 hours before the testing day. Subjects were instructed to avoid heavy breakfast and blood glucose level maintained between 4-6 mmol.L⁻¹. Subjects were instructed not to ingest fluid for 8 hours prior to the hypohydrated condition trials (HYH & HYT). For euhydrated condition trials (EUH & EUT), subjects were instructed to ingest fluid at 6 ml.kg BW-1 every 2-3 hours a day before the trials. Upon arrival to the laboratory, urine sample of subjects were collected to ensure they were in euhydrated condition (USG<1.0100) for EUH and EUT trials, and in mild hypohydrated conditions (USG> 1.0200, body weight loss \leq 1%) for HYH and HYT trials.

Baseline measurements such as body weight, blood glucose level, resting HR, resting Blood Pressure (BP) and USG were measured were recorded before the commencement of the experiment trial. During the experimental trials, VO₂ and HR were constantly recorded. Rating perceived exertion (RPE) and thermal comfort sensation (TCS) (ASHRAE Std.55, 1966) were taken every 10 min during the exercise.

Skin temperature (T_{sk}) and core temperature (T_{core}) were monitored throughout the whole trial. T_{core} was measured using the sterile disposable indwelling temperature probe (YSI 400 Series; Mallinckrodt Medical, Kansas City, MO). The temperature probe was inserted 10 cm beyond the anal sphincter of the subject. The skin temperature sensors (i-button, Maxim) were placed on subject's arm, chest, thigh and back calf to measure the mean T_{sk} using the formula Tsk= 0.3 (Chest) + 0.3 (Arm) + 0.2 (Thigh) + 0.2 (Calf) (Ramanathan, 1964). Six ml per kg BW of water was prepared for the subject to drink in ad-libitum manner at the 20-min time point.

For ambient temperature control, three heated lamps were placed on top and surrounding the ergometer and ambient temperature were maintained at $\sim 35^{\circ}$ C with 64% rh for EUH and HYH trials. For EUT and HYT trials, ambient temperature was maintained at $\sim 23^{\circ}$ C with 44% rh. The consistency in temperature and humidity throughout the experimental trials were monitored using a thermohygrometer (Kestrel 4000, USA) every 5 min. Postexercise measurements on resting HR, BP, USG, body weight and blood glucose were collected again at the end of the trials.

Statistical Analysis

All data was analyzed using IBM SPSS

Statistics Window version 23. Statistical significant level was set at P< 0.05. Data was expressed as mean \pm standard deviation (SD) in the text, tables and figures. Two-way repeated measures ANOVAs were used to assess differences between trials across time for measured variables.

RESULTS

Heart Rate Responses

No significant difference was found between obese and normal weight groups in heart rate (HR) responses during 4 experimental trials. EUT and HYT trials showed lower HR readings compared to hot conditions (EUH & HYH).

For obese group with euhydrated state, HR responses in EUH were significantly higher than EUT after 20 min of exercise (131 vs 123bpm; p=0.037), whereas in hypohydrated state, HR was significantly higher in HYH than HYT after 10 min of exercise (127 vs 118 bpm; p<0.002) (0.95 vs 1.05% Δ BW) (Figure 1).



Figure 1. Heart rate for Obese group during all 4 trials (* denotes significant main effect between denotes significant main effect between EUH & EUT; # denotes significant main effect between HYH & HYT).

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For normal weight group with euhydrated state, HR responses in EUH were significantly higher than EUT conditions after 10 min of exercise (126 vs 121 bpm; p<0.025). HR in HYH trials were significantly higher than HYT trials at 0 min (83 vs 76 bpm; p<0.008) onwards in the normal weight group in hypohydrated state (1.10 vs 1.13% Δ BW) (Figure 2).

Oxygen Uptake (VO₂) Responses

The VO₂ remained constant throughout the

50 min of cycling during 4 experimental trials in both group. (Figure 3 & Figure 4).

Thermoregulatory Responses

T_{core}, (Figure 5 & Figure 6) and T_{sk} (Figure 7 & Figure 8) were similar in both hot and thermoneutral conditions in all 4 experimental trials. Sweat loss (Figure 9) in normal weight group was significantly greater than obese group (1.21% vs. 0.75% Δ BW; 1.70% vs. 0.99% Δ BW) in EUT and EUH trials (p=0.035; p=0.017, respectively).



Figure 2. Heart rate for Normal Weight group during all 4 trials. (* denotes significant main effect between EUH & EUT; # denotes significant main effect between HYH & HYT).



Figure 3. VO₂ for Obese group during all 4 trials (* denotes significant main effect between trials).

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Figure 4. VO2 for Normal Weight group during all 4 trials (* denotes significant main effect between trials).



Figure 5. T_{core} for Obese group during all 4 trials (* denotes significant main effect between trials).



Figure 6. T_{core} for Normal Weight group during all 4 trials (* denotes significant main effect between trials).

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Figure 7. T_{sk} for Obese group during all 4 trials (* denotes significant main effect between trials).



Figure 8. Tsk for Normal Weight group during all 4 trials (* denotes significant main effect between trials).





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Subjective Responses

The TCS for both obese and normal weight groups in hot condition trials were similar. For obese group with hypohydrated state, TCS was significantly higher than normal weight group in thermoneutral condition after 20 min of exercise (0.6 vs -0.4; p=0.016), whereas in euhydrated state, both groups showed no significant differences.

No significant difference was found between obese and normal weight groups in RPE responses during 4 experimental trials. For obese group with hypohydrated state, RPE responses in hot conditions were significantly higher than thermoneutral conditions state at the end of exercise (14.0 vs 12.2; p=0.002), whereas for normal weight group, RPE was significantly higher during last 10 min of exercise (12.2 vs 11.6; p=0.024).

DISCUSSION

Based on the results, the VO₂ reading for both groups remained constant, which capped at 50% of the subject's VO_{2max} throughout the whole experimental trials, besides that HR increased gradually and significant differences were found between hot and thermoneutral conditions for both groups indicating obese subjects displayed similar oxygen demands as they exercised under either hot or thermoneutral; either euhydrated or hypohydrated conditions. Transfer of heat through flowing blood is the most important heat exchange pathway in body (Gonzalez-Alonso, 2012). Heart rate can immediately react to a metabolic and environmental condition changes and

it is a reflection of demand for the body's circulatory system or it can be known as the immediate effector of complex vasomotor response of the body (Moran et al., 1995). The non-exercising muscles blood flow is reduced to meet the increased demand of skin blood circulation for heat dissipation when exercising under heat (Nielsen et al., 1993). Blood flow and blood volume redistribution from deep to superficial vessels must occur to facilitate the heat loss process which leads to increase of heart rate and vasodilation of the vessels (Rowell, 1983). When exercising under hot conditions, the heat from external setting had put on extra strain on the heart. The heart act as the main driving force in the body to drive bloods to all parts of body in order to increase the blood flow to facilitate the heat dissipation process which resulted in a gradual increase of HR, T_{core} and T_{sk} during all experimental trials. In the present study's result, it was found that with sufficient water ingestion prior to exercise in heat might reduce an individual's strain during the exercise when compared to hypohydrated states as the results showed similar physiological responses in hot and thermoneutral conditions for both obese and normal weight groups.

It is known that exercise caused a rise in heat production of muscles which leads to increase of metabolic rate especially in a warmer environment setting. Human body will automatically regulate the T_{core} to a constant level around (~37°C) (Boone, 2014). A 50 min moderate intensity exercise was associated with gradual increased in body T_{core} (Figure 5 & Figure 6) and there was a correlation between both body T_{core} and T_{sk} in hot condition trials (r=0.543, p=0.000) (Table 1). The T_{sk} for obese and normal weight groups were similar in all 4 trials with hot condition showing a higher mean T_{sk} reading as compared to thermoneutral conditions trials. When exercising in hot environment, it caused an increase in the body skin blood flow and sweat rate to enhance the heat dissipation process in the body. This is an automatic thermoregulatory response of human body to attain a balance between heat production and heat loss (Gagge & Gonzalez, 2010; Kenny et al., 2010). The body T_{core} acts as one of the most influencing homeostatic parameter in the body, it controls the body's cellular function and organismal survival ability. The central nervous system (CNS) will put the body T_{core} maintenance to priority when thermal increment is sensed by the receptors from either ambient or internal environment (Morrison, 2016). This explains the higher mean T_{sk} when subjects were exercising under EUH and HYH conditions due to the increased skin blood flow to facilitate the heat dissipation process. It is noticeable that in current study, the overall mean T_{sk} and T_{core} in obese groups were indeed lower than the normal weight group when exercising under heat condition. The adipose tissue in obese subjects may act as an insulator to heat and blunted the heat transfer process (Chudecka et al., 2014; Savastano et al., 2009). A higher body fat percentage in the obese group may result in a lower skin blood flow during heat exposure, which further lowers the mean T_{sk} as compared to normal weight group.

According to Sawka et al. (2007), hyperthermia and the development of dehydration may cause sodium imbalance which can results in lower aerobic exercise performance levels when exercising under heat. This study showed an increase of T_{core} for both group in all 4 trials throughout the 45 min exercise period. Lee et al. (2008) reported that a warm and humid environment might positively affect the T_{core} during exercise. However in the present study, no significant difference was found between both groups for T_{core}. Similar to the study conducted by Heikens et al. (2011), the study measured the T_{core} of both normal weight and obese individuals and no significant difference was found at the end of the study. Thomas (2015) also mentioned that weather condition would not affect the ability of human body to regulate its body temperature and no significant relationship was found between body fat percentage and sweat rate (p>0.05). In this present study, the greatest body weight changes were found in EUH condition among the 4 trials for both groups (Obese: $1 \% \Delta BW \& Normal$ Weight: $1.7\% \Delta BW$). The obese group was not sweating as much as expected in the hot conditions compared to other similar studies (Osayande et al., 2016; Podstawski et al., 2014). Normal weight group had produced more sweat as compared to obese group in EUH and EUT trials (EUH: 22.38 vs 17.99 L/min; EUT: 15.86 vs 13.80 L/min).

The overall T_{core} and mean T_{sk} were lower resulting in a lower sweating rate in

the obese group as compared to the normal weight group when exercising under hot condition. This could be explained that the body thermoregulatory system receptors were still adjusting to the stimulus receiving from internal and external environments and it has contributed to a lower physiological strain index (PSI) in the obese group. The circulatory and thermal components such as HR and T_{core} were used to obtain the PSI reading. From the obtained results, the overall HR and T_{core} in hypohydrated hot condition (HYH) were the highest among all 4 trials in both groups. It was noticeable that physiological strain is caused by $\geq 1\%$ of body fluid loss. RPE responses were highest when both groups were exercising in HYH condition. The obtained results shown that 50 min of exercise under hot conditions would induce a higher HR and T_{sk} while the T_{core} and VO₂ would remain constant throughout the exercising period. Although sweat loss rate in term of body weight changes in the normal weight group was significantly higher than the obese group but no significant was found in physiological responses when compared to the normal weight group. The obese group and normal weight group were showing similarities in all 4 physiological responses in HR, VO₂, T_{core} , T_{sk} throughout all 4 trials.

CONCLUSION

Having greater subcutaneous adipose tissues in obese individuals did not impose greater thermoregulatory and circulatory strain during exercise in the heat. With \sim 1% of BW loss prior to exercise, the heart rate (HR), oxygen uptake (VO₂), core body temperature (T_{core}) and skin temperature (T_{sk}) in obese individuals were similar as normal weight individuals when exercising for 50min at 50% VO_{2max} of cycling in the heat (35°C; 64% rh). Therefore, exercise programme for obese individuals should not be restricted to indoor exercises only. Obese individuals can enjoy exercising outdoors, which have greater feelings of revitalization, increased energy and positive engagement.

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Table 1

Pearson Product-moment Correlations between Core temperature and Mean Skin temperatures when exercising under hot conditions.

| | | T _{core} |
|----------------------|-----------------|-------------------|
| Mean T _{sk} | r value | 0.543** |
| | sig. (2-tailed) | 0.000 |
| | | |

**. Correlation is significant at the 0.01 level (2-tailed)

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Effect of Technology Based Programme "Brain Breaks" on the Pupils'Attitudes towards Physical Activity in Secondary Schools

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ABSTRACT

This study examines effects of the technology-based physical activity intervention program on the attitudes of secondary school pupils towards physical activity. A total of 229 Grade 6 pupils participated in the study. The experimental group completed a 3-month intervention of a 3-5 min physical activity break during a random lesson every school day. A standardized questionnaire (51 items) was used to collect the data on a cognitive, affective and behavioral component of pupils' attitudes before and after the intervention. The control group only filled in the survey without taking part in the physical activity program. A paired samples t-test was applied to identify the differences between the pre-test and post-test data. The

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ISSN: 0128-7702 e-ISSN: 2231-8534 One-way ANOVA was used to compare two indepenten samples, differences between the experimental and the control group. As a result, significant differences between the pre-test and post-test were found in overall attitudes of the experimental group in both boys (p = 0.025) and girls (p = 0.039), and additionally, in the affective component in boys (p = 0.009) and girls (p = 0.002). Moreover, significant differences between the experimental and the control group were found in pupils' overall attitudes (boys p = 0.002; girls p = 0.007), in the affective component in boys (p < 0.001), and in the affective (p = 0.003) and behavioral (p = 0.024) component in girls. To conclude, such intervention programs may serve as a valuable tool to enhance pupils' attitudes towards physical activity which may lead to their greater active participation in physical activity, and consequently, an improved overall health.

Keywords: Attitudes, physical activity, pupils, secondary schools, technology based programme "Brain Breaks", video-exercise

INTRODUCTION

New technologies affect different areas of life of a current modern civilization. Their influence can often be perceived as positive (Bendikova, 2014; Fox, 1999). However, in case of their impact on an increase or a decrease of physical activity of children and youth the perceptions are rather negative (Lakdawalla & Philipson, 2009; Subrahmanyam et al., 2000). The causes of a decrease in a physical activity volume are associated with the environmental factors, increasing number of school subjects as well as a number of academic lessons per week, increasing number of hours devoted to homeworks, frequent health problems and exemptions from Physical education (PE). The children spend significant amount of time being sedentary, e.g. studying, watching TV, sitting at the computer, tablet or smartphone what reduces possibilities to be physically active (Cooper et al., 2015; European Commision, 2018; Inchley et

al., 2017; Janssen et al., 2004; Seman, 2009). The national education programs often support time allocation for academic subjects to the exclusion of PE. Similarly, to many other European countries, in Slovakia the number of PE classes is limited to two a week. Since the children and youth spend majority of the day in school, the school environment is ideal for introducing programs that will change the trend of physical inactivity among them.

Data suggest the importance of finding new ways of promotion and encouragement of regular physical activity and its integration during the school day. Classroom-based physical activity is a promising way of encouraging in-school physical activity of pupils (Rasberry et al., 2011). It was confirmed positive effect of classroombased physical activity interventions on academic and physical activity outcomes (Fedewa & Ahn, 2011; Watson et al., 2017). Implemented classroom physical activity breaks improved student physical activity during school and behavior in the classroom (Carlsona et al., 2015).

Due to an excessive interest of current young generation in information and communication technologies, their integration into physical activity seems like a promissing way how to motivate pupils to get involved. Short, classroom- and technology-based physical activities may be applied both in a recess and in the academic lessons (Cloes & Mornard, 2014; Podnar & Novak, 2015; Tumynaitė et al., 2014). Applied Brain Break® video exercises as an interventional program can have positive effects on interest and motivation for physical activity among schoolchildren and the contribution of such activities on learning for health and holistic development (HOPSports® Inc., 2017b; Popeska et al., 2018; Uzunos et al., 2017). We assume that this may be one of the ways to form pupils' interest in and attitudes towards physical activity which may lead to their spontaneous engagement into physical activity in their leisure time.

Boroš (2001) defined attitudes as a relatively permanent characteristics of individuals who expressed their opinion (positive or negative) to a certain area of reality and they reflected not only the basic cognitive orientation, but also the value system of a man and his effort orientation. This means that we take an attitude towards all things, actions, people and ourselves. In this sense, the attitudes are a factor that strongly influences the behavior of an individual.

Large number of authors (e.g. Boroš, 2001; Rosenberg & Hovland, 1960) follow the understanding of the 3-component structure of the attitude - cognitive, affective and behavioral. The cognitive component is connected to the rational evaluation of the subject of the attitude. Most frequently this component is created through the takingover of the opinions of other people. The affective (emotive / emotional) component reflects the emotional relation to the subject of the attitude, and it is more frequently created by the personal experience with the subject of the attitude. Thirdly, the behavioral component is demonstrated in the tendency to act, react in a certain manner to the subject of the attitude within the meaning. This component of the attitude results from the two previous ones (Nakonečný, 2009).

The aim of our research was to examine the efficiency of three-month multimediabased physical activity program on the attitudes of 10- to 12- years old pupils from secondary schools. We assumed that intervention of a three-five minutes physical activity breaks during academic lessons daily would have a positive impact on pupils' attitudes towards physical activity, both in boys and girls.

METHODS

A pedagogical experiment was applied as research method. A total of 229 pupils (115 boys, 114 girls) from 6 schools in Bratislava participated in the study. The participants were Grade 6 secondary school students of the average age 11.18 ± 0.77 years. The experimental group consisted of 58 girls (EG-G) and 65 boys (EG-B), and the control group comprised 56 girls (CG-G) and 50 boys (CG-B). The characteristics of the study sample is shown in Table 1. There were no significant differences in somatic parametres found between the experimental and the control group, both in boys and girls.

Before and after the intervention, the experimental and the control group were asked to fill in the standardized questionnaire oriented to the attitudes of the secondary school pupils towards physical activity (Sivák et al., 2000). This questionnaire was accredited and recomended by Ministry of Education of The Slovak Republic since 2000 and it has

Table 1Selected characteristics of study sample

| | Experim | ental group | Control group | | | |
|------------------|-----------------|-----------------|-----------------|-----------------|--|--|
| | Girls | Boys | Girls | Boys | | |
| Number | 58 | 65 | 56 | 50 | | |
| Age (years) | 11.26 ± 0.71 | 11.17 ± 0.76 | 11.05 ± 0.75 | 11.24 ± 0.87 | | |
| Body height [cm] | 154.60 ± 9.28 | 154.48 ± 7.89 | 155.54 ± 7.87 | 156.50 ± 7.74 | | |
| Body weight [kg] | 40.24 ± 7.26 | 43.52 ± 7.92 | 40.09 ± 7.00 | 43.66 ± 7.77 | | |

Notes: The values are in format $M \pm SD$.

been repeatedly used in different national surveys of the Slovak population (Balga & Antala, 2015; Bartík, 2005; Görner & Starší, 2001; Mesiarik et al., 2012). The questionnaire consisted of 51 items with a focus on three components of the attitude - cognitive, affective and behavioural (Validity = 0.72, Reliability=0.81). Each component was investigated by 17 questions and consequently awarded by two points (max. 102). The experiment was conducted from March - May in the school year 2016/2017. The distribution of the questionnaire was implemented after an approval of and an agreement with the school directors in cooperation with the class teachers.

During the intervention period, in the experimental groups the class teachers conducted a three-five minutes classroombased physical activity on a daily basis. It was conducted at any time during a 45-minute academic lesson with the help of video animations. In reality, this intervention plan was accomplished at 70% (48 times, 240 minutes). The pupils stood up next to their work place and imitated video animations projected to the board. The remaining time of the academic lesson in the experimental classes, and the entire academic lesson in the control classes, was conducted according to the curriculum of the appropriate subject.

The video-clips were created by volunteers from different countries all over the world and processed by HOPSports® Inc. within an international project "On-Line-Streaming Brain Breaks" (OLSBB). HOPSports® Inc. (2017a, 2017b) developed an innovative physical activity program for schools which provides teachers with a tool for encouraging learning and an active participation of the pupils in the class through integration of physical activity and subject content. It enables teachers to physically engage pupils in a simple and fun way during the school day with a dynamic activity and potentially improve pupils' health, motivation, memory, on-task behavior and academic achievement.

The research was accredited by Ethic commision of Faculty of Physical Education and Sport, Comenius University in Bratislava on September 9th, 2016 with number 05/2016.

Before the experiment, classroom teachers attended a training session. They were informed about the organization and conduct of a Brain Break classroombased physical activity. The teachers were provided with a username and password for accessing the video animations and were given an instruction sheet with simple guidelines.

The IBM SPSS Statistics 23 was used to proceed the data. Selected quantitative parameters were characterised by an arithmetic mean (M) and a standard deviation (SD). Kolmogorov-Smirnov test was used to determine whether sample data are normally distributed. A paired samples t-test was applied to identify the differences between the pre-test and post-test data. The One-way ANOVA was used to compare two indepenten samples, differences between the experimental and the control group. We used an alpha level of 0.05 for all statistical test. Cohen's d and Hedges' g was used to determine the effect size.

RESULTS

Data evaluation enabled us to obtain the results for a comparison of the significance of differences in the score mean values in the individual components of pupils' attitudes to physical activity at the beginning (pre-test) and at the end (post-test) of the intervention period.

Results – Boys

When comparing pre-test score in boys, no significant differences were found between the experimental and the control group. Although the overall score of the experimental group (M = 73.52, SD = 14.89) was slightly higher than the score of the control group (M = 70.36, SD = 16.75), this 4.30% difference was not statistically significant, F(1, 113) = 1.14, p = 0.287.

Similarly, the pre-test data did not show any significant differences in the attitude's individual components (cognitive, affective and behavioral) between the experimental and the control group in boys (Table 2). The biggest difference – 2.02 points (8.04%) was found in the behavioral component of an attitude. On the contrary, the smallest difference, only 1.82% (0.44 point), was found in the attitude's cognitive component.

It follows that at the begining of the experiment the boys' attitudes of the experimental and the control group towards physical activity were even.

With respect to boys' attitudes after the intervention, the post-test data showed significant differences in overall score between the experimental (M = 76.45, SD = 13.24) and the control (M = 65.96, SD = 15.51) group, F(1, 113) = 15.26, p < 0.001. The experimental group achieved higher score by 10.49 points (13.72%) compared to the control group (g = 0.74, medium effect).

Similarly, the differences between the experimental and the control group of boys were significant in the attitude's affective (F(1, 113) = 19.42, p < 0.001) and behavioural (F(1, 113) = 13.23, p < 0.001) component (Table 2). The experimental group achieved higher score than the control group in the affective component by 19.98% (5.26 points) what was considered difference of large effect (g = 0.83). In addition, in the behavioral component

Table 2

Significance of differences in score mean values of attitude's individual components to physical activity in boys

| | | Score of attitude's components in boys | | | | | | | | | |
|-------------------|---------------------------------------|--|------------|---------------------------------------|-----------|------------|---------------------------------------|-----------|------------|--|--|
| | Cogniti | ve | | Affecti | ve | | Behavioral | | | | |
| | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | | |
| | Experii | nental g | roup - ba | ys (n = 6 | 5) | | | | | | |
| М | 23.72 | 24.31 | 0.59 | 24.68 | 26.32 | 1.64 | 25.12 | 25.82 | 0.70 | | |
| SD | 4.72 | 4.34 | 4.23 | 6.91 | 5.99 | 4.90 | 5.91 | 5.33 | 5.10 | | |
| | t(64) = 1.12 p = 0.269 d = 0.13 | | | t(64) = 2.71 p = 0.009 d = 0.25 | | | t(64) = 1.10 p = 0.277 d = 0.12 | | | | |
| | Contro | l group - | boys (n = | = 50) | | | | | | | |
| М | 24.16 | 22.88 | - 1.28 | 23.10 | 21.06 | - 2.04 | 23.10 | 22.00 | - 1.10 | | |
| SD | 4.71 | 5.22 | 5.80 | 7.68 | 6.79 | 5.09 | 6.70 | 5.89 | 5.68 | | |
| | t(49) = 1.56 p = 0.125 d = 0.26 | | | t(49) = 2.83 p = 0.007 d = 0.28 | | | t(49) = 1.37 p = 0.177 d = 0.17 | | | | |
| | Experii | nental g | roup to c | ontrol gi | oup comp | arison | | | | | |
| <i>F</i> (1, 113) | 0.24 | 2.56 | 3.67 | 1.34 | 19.42 | 15.46 | 2.94 | 13.23 | 3.16 | | |
| р | 0.623 | 0.112 | 0.059 | 0.250 | < 0.001 | < 0.001 | 0.089 | < 0.001 | 0.078 | | |
| g | 0.09 | 0.30 | 0.38 | 0.22 | 0.83 | 0.74 | 0.32 | 0.68 | 0.34 | | |

Notes: M – arithmetic mean; SD – standard deviation; p – level of statistical significance; t - paired samples t-test; F - One way ANOVA; d – Cohen's d; g – Hedges' g

the experimental group achieved higher score by 14.80% (3.82 points) what was a difference of medium effect (g = 0.68). On the contrary, although the experimental group achieved higher score also in the cognitive component, the 5.88% difference between the groups was not significant, F(1, 113) = 2.56, p = 0.112.

A comparison of the pre-test and posttest data in the experimental group of boys shows a significant increase in the overall score, t(64) = 2.30, p = 0.025 as well as in the affective component of the attitude, t(64) = 2.71, p = 0.009. Due to the intervention program the experimental group's overall score increased by 3.99% (d = 0.21, small effect), (Figure 1). During the intervention period the score of all 3 attitude's components increased, however the difference was significant only in the affective one. During the intervention period the score increased by 6.65% (d = 0.25,small effect), (Figure 2).

In the control group of boys the comparison between pre-test and post-test data shows that all four measured parameters

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Notes: EG-B - experimental group of boys; CG-B - control group of boys

Figure 1. Differences in the overall score of attitudes to physical activity between pre-test and post-test data in experimental and control group of boys



Notes: EG-B - experimental group of boys; CG-B - control group of boys

Figure 2. Differences in the affective component of attitude to physical activity between pre-test and post-test data in experimental and control group of boys

decreased throughout the intervention period (Table 2). The boys achieved a significant decrease in the attitude's affective component by 8.83% (p = 0.007, d = 0.28, small effect), (Table 2, Figure 2), as well as in the overall score (pre-test M=70.36, SD = 16.75; post-test M = 65.96, SD = 15.51) of the attitudes towards physical activity (p = 0.024, d = 0.27, small effect), (Figure 1).

Most importantly, the comparison of changes in the experimental and the control group shows significant differences in overall score (experimental group M = 2.92, SD = 10.27; control group M = -4.40, SD = 13.31), F(1, 113) = 10.38, p = 0.002, g = 0.63 (medium effect) and the attitude's affective component to physical activity (p < 0.001, g = 0.74, medium effect), (Table 2).

In conclusion, the 3-month Brain Break intervention program had a positive impact

on the boys' overall attitudes towards physical activity, affective component of the attitude in particular.

Results – Girls

A comparison of pre-test data prior to intervention did not show any significant differences in the attitudes towards physical activity between the experimental and the control group of girls. Although not siginificant, the control group (M = 74.75,SD = 16.72) achieved higher overall score of the attitudes by 5.85% (4.37 points) compared to the experimental group (M = 70.38, SD = 15.63), F(1, 112) = 2.08,p = 0.152, including all 3 attitude's components, the affective one in particular (9.96% difference). Similarly, a comparison of the post-test data did not show any differences of statistical significance in the attitudes between the experimental and the control group of girls (Table 3).

| Table | 3 |
|-------|---|

| Significance of differences in score mean | values of attitude's individua | l components to physical | activity in girls |
|---|--------------------------------|--------------------------|-------------------|
| 0 1 1 10 | v | | , 0 |

| | Score of attitude's components in girls | | | | | | | | | | |
|--|--|-----------|------------|-----------------------------------|---------------------------------------|---------------------|----------|---------------------------------------|------------|--|--|
| | Cogniti | ve | | Affectiv | /e | | Behavio | oral | | | |
| | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | | |
| Experimental group - girls (n = 58) | | | | | | | | | | | |
| М | 23.64 | 23.83 | 0.19 | 22.43 | 24.48 | 2.05 | 24.31 | 24.95 | 0.64 | | |
| SD | 5.10 | 5.31 | 4.52 | 6.89 | 7.12 | 4.73 | 6.31 | 6.82 | 5.08 | | |
| | t(57) = 0.32 	 tv p = 0.750 	 p d = 0.04 	 a | | | t(57) = 1 p = 0.00 d = 0.29 | t(57) = 3.31 p = 0.002 d = 0.29 | | | t(57) = 0.96 p = 0.343 d = 0.10 | | | |
| | | | | Contr | ol group - gi | rls (n = 56) | | | | | |
| М | 24.52 | 23.95 | - 0.57 | 24.91 | 23.88 | - 1.03 | 25.32 | 23.89 | - 1.43 | | |

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| | Score of attitude's components in girls | | | | | | | | | |
|------------------|---|-------------|------------|-----------------|------------|---------------|--------------|-----------|------------|--|
| | Cogniti | ve | | Affectiv | ve . | | Behavi | oral | | |
| | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | Pre-test | Post-test | Difference | |
| | Control group - girls (n = 56) | | | | | | | | | |
| SD | 5.04 | 5.66 | 5.34 | 6.81 | 7.13 | 5.97 | 6.29 | 5.61 | 4.57 | |
| | i | t(55) = 0.8 | 0 | t(55) = 1.30 | | | t(55) = 2.34 | | | |
| | p = 0.426 | | | <i>p</i> =0.199 | | | p = 0.023 | | | |
| | | d = 0.11 | | | d = 0.13 | 5 | d = 0.24 | | | |
| | | | Experi | mental gr | oup to con | trol group co | mparison | | | |
| <i>F</i> (1,112) | 0.86 | 0.01 | 0.68 | 3.74 | 0.21 | 9.42 | 0.73 | 0.81 | 5.20 | |
| р | 0.357 | 0.908 | 0.412 | 0.056 | 0.650 | 0.003 | 0.393 | 0.370 | 0.024 | |
| g | 0.17 | 0.02 | 0.15 | 0.36 | 0.08 | 0.57 | 0.16 | 0.17 | 0.43 | |

Notes: M – arithmetic mean; SD – standard deviation; p – level of statistical significance; t - paired samples t-test; F - One way ANOVA; d – Cohen's d; g – Hedges' g

Similarly, to boys, in the experimental group of girls the classroom-based physical activity program contributed to a significant increase in overall score of the attitude and its affective component towards physical activity. The overall score (pretest M = 70.38, SD = 15.63; post-test M = 73.36, SD = 17.08) increased by 4.23%, t(57) = 2.11, p = 0.039 (Figure 3). The attitude's affective component increased by 9.14% (p = 0.002, d = 0.29, small effect), (Figure 4). The control group of girls achieved a significant decrease in the attitude's behavioral component (p = 0.023, d = 0.24, small effect), (Table 3). The other two components as well as the overall score decreased as well but the difference was not significant (Table 3, Figure 3).

A comparison of the experimental and the control group's changes in attitudes towards

physical activity confirmed the efficiency of the classroom-based physical activity program in girls (Table 3). The experimental group's increase (M = 2.98, SD = 10.75) was significantly greater compared to the control group (M = -3.09, SD = 12.82) in the overall score, F(1, 112) = 7.52, p = 0.007, g = 0.51 (medium effect). Furthermore, the experimental group's increase was greater in the behavioral component (p = 0.024, g = 0.43, small effect) and in the affective component of the attitude in particular (p = 0.003, g = 0.57, medium effect), (Table 3).

To conclude, similar to boys, the Brain Break intervention program in a duration of three months positively influenced girls' attitudes towards physical activity in general, particularly the affective component of the attitudes. Ľubor Tománek, Iveta Cihová, Gabriela Luptáková, Branislav Antala, Ming-kai Chin and Peter Šagát



Notes: EG-G – experimental group of girls, CG-G – control group of girls *Figure 3*. Differences in the overall score of attitudes to physical activity between pre-test and post-test data in experimental and control group of girls



Notes: EG-G - experimental group of girls, CG-G - control group of girls

Figure 4. Differences in the affective component of attitude to physical activity between pre-test and post-test data in experimental and control group of girls

DISCUSSIONS

Over recent decades, a steadily growing body of literature has indicated the need to examine the positive effects of incorporating classroom-based physical activity among pupils and educators (Podnar, 2015). Several studies carried out in different parts of Slovakia refer to pupils' attitudes towards physical activity in gerenal. A majority of such papers are focused on the attitudes towards physical education as a school subject, however without a prior intervention. Based on the results, students' attitudes towards physical education are rather positive (Balga & Antala, 2015; Bartík, 2005; Görner & Starší, 2001). In this context we can compare our findings with the abovementioned studies only to a certain extent. The standardized questionnaire (Sivák et al., 2000) that was used to collect the data is a common tool to examine pupils' attitudes in Slovak and Czech environment, and our pre-test data show similar attitudes of pupils to other studies of this kind. The affective component of the attitude is the one that was positively affected by our intervention program the most. One of the hypothetical reasons might reside in the Brain Break program's relaxing effects.

A number of intervention studies with application of HOPSports Brain Break program focus on pupils' attitudes to different parameters of physical activity in the foreign countries (Glapa et al., 2018; Podnar, 2015; Podnar & Novak, 2015; Tumynaitė et al., 2014), where the results demonstrate positive impact of the program on the attitudes and other selected parameters. The QPA questionnaire (Mok et al., 2015; Uzunoz et al., 2017) was used to collect the information on attitudes and other standards from the pupils and pedagogues. An appropriate translation procedure and its verification is a necessary condition for the application of such tool of investigation (Hulka et al., 2014).

CONCLUSIONS

The results of our study advert to the efficiency of a classroom- and technologybased physical activity program on secondary school boys' and girls' attitudes towards physical activity. The experimental group took part in the intervention program daily for three months while the control group did not. Both groups filled in a standardized questionnaire on attitudes and its three components (cognitive, affective, behavioral) to physical activity.

In case of the boys' overall attitudes after the intervention (post-test), the results showed significantly more positive attitudes of the experimental group (M = 76.45, SD = 13.24) in comparison to the control group (M = 65.96, SD = 15.51) by 13.72%, F(1, 113) = 15.26, p < 0.001, g = 0.74(medium effect). Additionally, the difference was significant in favour of experimental group in the behavioral component of the attitude (p < 0.001, g = 0.68, medium effect) and particularly in the affective component with a large 19.98% difference (p < 0.001, g = 0.83, large effect).

The girls' attitudes towards physical activity after the intervention were similar to the boys' ones. Furthermore, the differences between the data collected before (pre-test) and after (post-test) the intervention were compared among the groups of girls. The experimental group's increase in the score was significantly greater compared to the control group in three cases: firstly, the overall score of the attitudes (p = 0.007, g = 0.51, medium effect), secondly, the behavioral component of the attitudes

(p = 0.024, g = 0.43, small effect) and thirdly the affective component (p = 0.003, g = 0.57, medium effect).

Our results confirmed the hypothesis that short, technology- and classroom-based physical activities during academic lessons may positively affect pupils' attitudes towards physical activity in general. These findings support other studies in this area and contribute to the enrichment of sport science with a special focus on physical activity programs in school settings, physical activity and new technologies, new technologies in teaching profession and teacher training.

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Relationship between Personality Traits and Physical Activity Participation

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ABSTRACT

Objective of the study was to explore the affiliation amongst the Personality Traits and physical activity participation based on Area of Study, Program Level and Year of Program and Type of Physical Activity (Group and Individual Activities). Two hundreds and five 205 participants (117 males and 88 females; M age = 20.69; SD = 1.465) from a local institution of higher learning in Malaysia partook in this study. Participants completed two inventories: Godin-Shepard Leisure-Time Exercise Questionnaire by Godin & Shepard (1985) and the Big-Five Inventory by John & Srivastava (1999) for data collection. Findings indicated that Extraversion (r = 0.160, p = 0.022) and Openness (r = 0.148, p = 0.034) were positively correlated with physical activity participation. Extraversion based on Area of Study was also significant (F (5,199) = 2.750; p = 0.020). Gender (M = 23.92,

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E-mail addresses cynthiaac@tarc.edu.my (Cynthia Anne Cornelius) johnnynkm95@gmail.com (Ng Khai Meng) *Corresponding author SD = 5.864, p = 0.035); type of physical activity (M = 23.92, SD = 5.864, p = 0.047) and area of study (F (5,199) = 5.454, p = 0.000) were significant for Neuroticism. Age group (M = 23.92, SD = 5.864, p = 0.005) was significant for Openness. This study indicated that personality traits are one of the contributing factors that attribute towards physical activity participation on an individual.

Keywords: Big five personality traits, physical activity participation, University students

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INTRODUCTION

Regular physical activity participation and its benefits for an individual's mental and physical health have been well-recognized and documented in studies (e.g. Trost et al., 2002; Kilpatrick et al., 2005; Janssen & LeBlanc, 2010). Malaysia as a developing and industrialized country has led to rapid changes in an individual's lifestyle, where Malaysia reported the highest obesity rates in Southeast Asia (Chan et al., 2017), with a total of 44% men and 49% women were discovered to be obese and the likelihood of being overweight was 45% in Malaysia ("Malaysia's obesity", 2014). Ghee (2016), pointed out that the number of overweight individuals' had increased by more than 60% over the years from 1996 to 2003 and is now an ongoing issue that plagues developing countries. All these findings pointed at the ongoing changes in lifestyle habits practiced by Malaysians and increased concern. To boost participation in sport and exercise, it has led to numerous attempts seeking to identify the various factors linked with regular physical activity participation from a psychological perspective.

Personality is seen to play a contributing factor that affects exercise frequency or physical activity participation (Lewis & Sutton, 2011; Rhodes & Smith, 2006; Wilson & Dishman, 2014) of an individual; pointing towards the interconnection between personality and physical activity (Allen et al., 2016; Allen & Laborde, 2014). An individual's personality may be one of the factors contributing to physical inactivity (Ebstrup et al., 2013) or high levels of physical activity participation (Stephan et al., 2014). Agreeableness, Neuroticism, Extraversion, Conscientiousness, and Openness have been used extensively to evaluate the relationship amongst personality and physical activity participation (Lochbaum et al., 2007; Siegler et al., 1997) as these five personality domains encompass a number of more specific traits that are defined as facets (Allen et al., 2013). Besides that, epidemiological evidence pointed at the drop in physical activity levels when transitioning from secondary to tertiary education (Kilpatrick et al., 2005) that is caused not only due to a change in their environment but also in their personalities as well. McAdams and Olson (2010) stated that individuals between the ages of 18 and 30 usually demonstrated the utmost change in their personalities due to transitioning to young adulthood from adolescence where they usually would indicate a rise in Conscientiousness and Agreeableness but a drop in Neuroticism. This is critical as it may reflect the shift in physical activity participation levels across an individual's lifespan. Lüdtke et al. (2011)'s study indicated an increase in Openness as they typically became more matured and accustomed, emotionally stable and accountable (Leikas & Salmela-Aro, 2015). However, there seems to be an inconclusive correlation between physical activity participation and certain personality traits (Rhodes & Smith, 2006; Wilson & Dishman, 2014). Furthermore, Allen and Laborde (2014), pointed out that this might be due to personality traits seen as precursors to physical activity levels

instead of the bidirectional associations where participation in physical activity might contribute towards changes in an individual's personality makeup. The shift to tertiary from secondary education is not a stress-free process and can be taxing most of the time due to academic pressure and time management. Whereas Kutty et al. (2015) emphasized the likelihood of reduced changes that an individual might participate in healthy behaviors such as physical activity and proper dietary habits. This is mainly due to the importance and emphasizes that parents place on academic excellence instead of motivating their children to be more active physically (Kelishadi et al., 2010). El-Gilany et al. (2011) carried out a study on 1708 University students in Egypt backed this assertion as around 41% of students testified time restrictions due to the priority placed on academic excellence by parents. Furthermore, females have pointed out the issue of safety as a barrier towards physical activity participation, where feelings of insecurity to partake in physical activity due to the fear of facing unsolicited circumstances that may affect their safety (Kelishadi et al., 2010). Facility accessibility in the university is also one of the barriers to being active physically is mentioned due to the absence of sports amenities made available for students, poor upkeep of amenities and the fear (Kelishadi et al., 2010).

From the existing studies, the link between physical activity participation and personality is still inconclusive. Furthermore, there is a lack of current research done within Malaysia in regards to the relationship and impact of the personality traits towards physical activity participation among young adults based on their modes of physical activity. Young adulthood is important in an individual's developmental stage where they not only display a great change in physical activity level but also the most changes to their personalities. Therefore, our purpose was to further understand the relationship of different personality traits on physical activity participation choices and to further explain the dynamic and complex relationship tying both an individual's personality and physical activity participation levels together.

METHODOLOGY

Subjects

A convenience sample of 117 males and 88 females (205 subjects; M age = 20.69; SD = 1.465) were recruited from a local institution of higher learning in Malaysia. Subjects of this research were informed that participating in this study was done voluntarily and any data collected were purely for scientific purposes.

Measures and Instruments

Personality. Personality traits were assessed using the 44-item version of the Big Five Inventory (BFI; John & Srivastava, 1999), using a 5-point Likert scale, ranging from 5 = Agree Strongly, 4 = Agree a Little, 3 = Neither Agree nor Disagree, 2 = Disagree a Little, 1 = Disagree Strongly. The Big-Five Inventory consisted of five expansive personality dimensions, namely Openness (10-item), Agreeableness (9item), Extraversion (8-item), Neuroticism (8-item) and Conscientiousness (9-item). However, there were no reported local reliability and validity for the instrument. A pilot study did for BFI showed a strong validity and reliability; and reported as follows, Openness (0.65), Agreeableness (0.57), Extraversion (0.75), Neuroticism (0.85), and Conscientiousness (0.70).

Physical Activity. The physical activity level of participants' were assessed using the 4-item self-administered Godin-Shepard Leisure-Time Exercise Questionnaire (GSLTEQ; Godin & Shepard, 1985; Gordin, 2011). Completion of the questionnaire was based on a 7-day period of at least 15-minutes of physical activity according to the number of times one partakes in mild, moderate, and strenuous leisure-time physical activity. The scores of the number of times one partook in mild, moderate, and strenuous intensity multiplied by a corresponding Metabolic Equivalent of Task (MET) value, such as 3, 5 and 9 respectively provided the scores for each activity. Leisure score indexes (LSI) obtained was by summing up all three scores expressed in arbitrary units. GSLTEQ showed the reliability of 0.97 (Sari & Erdogan, 2016) and was considered valid and reliable locally (Kok et al., 2010).

Procedure

Approval from the Ethics Committee of the local institution of higher learning obtained allowed this research study to proceed forward. Subjects from each faculty were approached and enquired on their willingness to partake in this study. Subject's consent was acquired with a consent form that detailed the area, scope, and objective of study. Before answering the questionnaires, a copy of the consent form was given, that subjects were required to fill in. 3 questionnaires for the study detailing on (1) Participant Information (2) Big Five Inventory and (3) Godin-Shepard Leisure-Time Exercise Questionnaire took about 20 minutes to be completed and subjects were asked to answer all questions as truthful as possible. The researcher collected back all completed questionnaires.

Statistical Analysis

Data gained from the study were analysed using the SPSS version 21; basic descriptive statistics tabulated according to mean ± SD of the observed variables for personality traits and physical activity participation. A correlation analyses used looked at the association concerning personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness) and physical activity participation of individuals with correlation analysis. The differences in relevant variables were calculated utilizing the univariate analysis of variance and independent t-test.

RESULTS

Table 1 reports the descriptive information for all measured variables in relation to the demographic data of the participants.

| | | | Extraversion | Agreeableness | Conscientiousness | Neuroticism | Openness | |
|-----------|---|-----|-------------------|-------------------|--|--|--|--|
| | | Z | M±S.D | $M \pm S.D$ | $\mathbf{M} \pm \mathbf{S}.\mathbf{D}$ | $\mathbf{M} \pm \mathbf{S}.\mathbf{D}$ | $\mathbf{M} \pm \mathbf{S}.\mathbf{D}$ | |
| Condou | Male | 117 | 26.59±6.672 | 32.35±5.645 | 30.05 ± 5.580 | 23.19±6.231 | 33.36±5.502 | |
| Cellder | Female | 88 | 26.10 ± 5.083 | 31.72±5.328 | 29.36±5.173 | 24.89±5.216 | 32.81±4.889 | |
| Age Group | 17-20 | 88 | 25.85±6.037 | 32.23±5.381 | 29.67±5.403 | 24.08±5.865 | 31.93 ± 4.533 | |
| J | 21-24 | 117 | 26.78 ± 6.025 | 31.97±5.620 | 29.82±5.432 | 23.79±5.886 | 34.02 ± 5.571 | |
| | | | | | | | | |
| Level of | Diploma | 72 | 25.07±6.036 | 31.86±5.002 | 29.14±5.351 | 24.17±5.743 | 31.17 ± 4.965 | |
| Program | Degree | 133 | 27.09±5.933 | 32.20±5.77 | 30.09 ± 5.428 | 23.78 ± 5.946 | 34.18 ± 5.099 | |
| | Applied Sciences | 97 | 27.49±6.566 | 32.69±5.763 | 31.47±5.750 | 22.23±6.029 | 33.82±5.364 | |
| | Computing Sciences | 13 | 22.69±4.922 | 31.15 ± 3.648 | 29.46±4.013 | 29.69±4.111 | 31.00±5.115 | |
| Area of | Accounting, Finance, and Business | 58 | 25.79±4.690 | 30.57±5.154 | 28.36±5.046 | 25.55±5.219 | 32.16±4.720 | |
| Study | Engineering | Г | 27.29±4.645 | 32.86±4.059 | 34.29±3.450 | 23.29±4.348 | 34.29±7.342 | |
| | Built Environment | 6 | 22.22±5.118 | 32.67±3.808 | 29.44±3.877 | 27.22±5.333 | 34.56±3.745 | |
| | Social Sciences and Humanities | 21 | 26.62±6.793 | 33.48±6.638 | 29.10±5.638 | 23.05±5.408 | 34.14±5.525 | |

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Table 1 Descriptive statistics

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| Table 1 (Cont | inued) | | | | | | |
|----------------------------------|------------------------------------|-------------------------|---|--|-------------------|--|-------------------|
| | | | Extraversion | Agreeableness | Conscientiousness | Neuroticism | Openness |
| | | z | M±S.D | $\mathbf{M} \pm \mathbf{S}.\mathbf{D}$ | $M \pm S.D$ | $\mathbf{M} \pm \mathbf{S}.\mathbf{D}$ | $M \pm S.D$ |
| | Year I | 25 | 27.88±6.990 | 34.68 ± 4.516 | 31.16 ± 4.230 | 22.48±5.059 | 33.16±4.230 |
| Program | Year 2 | 94 | 25.97±5.956 | 31.72±5.462 | 29.71 ± 5.804 | 24.00 ± 6.142 | 32.13 ± 5.361 |
| Year | Year 3 | 78 | 26.29±5.880 | 31.72±5.578 | 29.42±5.246 | 23.87±5.546 | 34.18 ± 5.379 |
| | Year 4 | 8 | 27.38±5.476 | $31.63{\pm}6.906$ | 29.13±5.617 | 27.88±7.039 | 34.38±3.462 |
| Mode Physical | Individual Sport | 120 | 25.88±5.872 | 32.03±5.731 | 30.00±5.722 | 24.60±6.040 | 33.38±5.104 |
| Activity | Group Sport | 85 | 27.09±6.218 | 32.14±5.208 | 29.41 ± 4.941 | 22.95±5.499 | 32.76±5.442 |
| Table 2 rep personality | ports the corre traits and phys | lation re ical activ | sults between th ritv participation. | ē | | | |
| Table 2 <i>Relationship l</i> | between Personalit | ty Traits an | d Physical Activity F | articipation | | | |
| | | Extraver | sion | Agreeableness | Conscientiousness | Neuroticism | Openness |
| Physical Acti | vity Participation | 0.160^{*} | | 0.100 | 0.002 | -0.082 | 0.148* |

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*Correlation is significant at the 0.05 level (2-tailed)

Physical activity and different personality dimensions have been shown to have a bidirectional relationship (Allen et al., 2016), where it may be one of the reasons that contribute towards physical inactivity involvement (Ebstrup et al., 2013) or high levels of active involvement in physical activity (Stephan et al., 2014) in individuals. Ingledew and Markland (2008) stated that personality influenced the different motives towards participating in physical activities, sport or exercise. With that being said, it can be said that Study results had demonstrated that personality traits: Extraversion (r = 0.160, p = 0.022) and Openness (r = 0.148, p = 0.034)demonstrated a positive relationship with physical activity involvement of college students.

Extraversion looks towards one's tendency to find strong sensory stimulation

in the task/activities that they undertake. Study results demonstrated in terms of area of study that students undertook in their tertiary education were significantly different [F (5,199) = 2.750, p = 0.020]. The results highlight the varying personalities of students between different areas of study and university programs.

Neuroticism refers to the tendency of experiencing unpleasant and negative emotions (e.g. fear, anxiousness, pessimism, sadness, and insecurity). As observed from Table 4, the study results point out that based on gender, it was significantly different (M = 23.92, SD = 5.864, p = 0.035) and mode of physical activity (M = 23.92, SD =5.864, p = 0.047) was also significant when comparing between individual and group activities.

Openness assesses an individual's tendency to seek out new experiences and

| Extraversion and physic | cal activity participat | ion according to area of study |
|-------------------------|-------------------------|--------------------------------|
| | F | Sig. |
| Area of Study | 2.750 | 0.020* |

Table 4

Table 3

Neuroticism and physical activity participation according to gender and types of activity

| Measure | Category | Ν | Mean | SD | F | Sig. | |
|----------|--------------------------|-----|-------|-------|-------|--------|--|
| Caralan | Male | 117 | 23.19 | 6.231 | 4 029 | 0.025* | |
| Gender | Female | 88 | 24.89 | 5.216 | 4.038 | 0.055* | |
| Type of | Individual Activities | 120 | 24.60 | 6.040 | 1.022 | 0.047* | |
| Activity | Group Activities | 85 | 22.95 | 5.499 | 1.082 | 0.04/* | |

Note: SD = Standard Deviation; *p < 0.05, two-tailed test

| openness un | n physical ac | in ity pair iterpa | | 0 480 8.00p | | | |
|-------------|---------------|--------------------|-------|-------------|-------|--------|--|
| | | Ν | Mean | SD | F | Sig. | |
| A Current | 17-20 | 88 | 31.93 | 4.533 | 2 (2(| 0.005* | |
| Age Group | 21-24 | 117 | 34.02 | 5.571 | 2.030 | 0.005* | |

Table 5Openness and physical activity participation according to age group

Note: SD = Standard Deviation; *p < 0.05, two-tailed test

ideas. Our results showed that according to age group it was significant (M = 23.92, SD = 5.864, p = 0.005). This highlights the association between openness and the level of involvement in physical activity across an individual's lifespan.

DISCUSSION

Results (Table 2) from the study showed that there were no correlations between personality traits: Agreeableness, Neuroticism, and Conscientiousness with physical activity participation among college students. The relationship between physical activity and extraversion is due to the person's tendency to seek strong sensory stimulation by being involved in physical activity as a means of feeding their desire of being active physically, desiring positive feelings and sensory stimulations (Rhodes & Smith, 2006). Tolea et al. (2012) and Wilson & Dishman (2014) stated that extrovert individual's motives towards participating in physical activity were not just to obtain the benefits of physical activities, but it might also be due to the need to feed their social and outgoing characteristics by exposing themselves in different environments.

The link between physical activity participation and openness between college students showed similar results as other prior research (Rhodes & Smith, 2006;

Wilson & Dishman, 2014). According to Table 5, results showed that individuals with high levels of openness were more receptive, flexible, curious, imaginative and broad-minded towards new experiences and activities which could motivate individuals towards a variety of social activities and developed an understanding to the benefits of physical activity participation (Ingledew & Markland, 2008), which increased their engagement in physical activity (Rhodes & Smith, 2006). Adolescence and the transition stage from high school to tertiary education are a critical developmental stage where one undergoes the greatest changes in personality (McAdams & Olson, 2010). Participation in physical activity or sports of a high level of extraversion and openness individuals are more likely to engage in any form of activities from physically demanding activities to sedentary activities such as seeing movies and engage in it continuously.

Neuroticism refers to the negative emotional states of the individual where our results showed a significant difference between physical activity participation and neuroticism according to gender. Results (Table 4) obtained were similar to the findings from previous research when comparing personalities between sexes, where males had lower neuroticism compared to females (Costa et al., 2001; Weisberg et al., 2011). According to Stake and Eisele (2010), this may be because women are more likely to face more depression and nervousness as the neuroticism domain encompasses a wide-ranging of mental health variables, such as depression, anxiety and insecurities. However, it is important to note that regular participation in social activities from physical exercise groups to daily socialization among friends could have adverse effects on an individual that includes body-image concerns and disordered eating behaviour. High levels of neuroticism may be a factor that inhibits individuals from their attempts to participate in social activities and or even reduces their exposure to physical activity (Wilson & Dishman, 2014).

CONCLUSION

The study findings demonstrated that Extraversion and Openness were positively related to the college students' physical activity participation as found in previous researches. The results support that personality traits may be a factor contributing to an individual's physical activity participation based on gender, mode of physical activity and age groups. In short, one's involvement in physical activity can be determined or affected by one's personality traits. However, the participants' age range may include a wider range and should cover adolescents and young adults from tertiary education and high school to highlight the transition phase from adolescence to young adults.

Further studies are also required to identify the relationship between personality traits and the mass population's physical activity participation and prolonged involvement.

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Does Duration of Rest Interval Affect 1-RM Bench Press Test?

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ABSTRACT

Bench press 1-RM test is a common assessment to measure maximal strength of the upper body musculatures. Most protocols recommend a rest period between the maximum contraction trials to avoid fatigue which may confound the assessment. Factors that influence fatigue are strength level and fatigue recovery rate especially among sedentary population. The objective of this study was to determine the optimal resting period required among sedentary population when assessing upper body strength using the common 1-RM test, and whether gender influenced the findings. In a randomised, cross-over design, thirty (15 males and 15 females) sedentary participants, aged 18 to 24 years underwent 1-RM bench press tests using machine weight and free weight with different rest period between the 1-RM trials (1-min, 3-min, 5-min). The participants lifted a significantly (p < 0.05) heavier weight when given 3-min rest for both machine weight test (47.16 ± 26.86)

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E-mail addresses Ashril Yusof (ashril@um.edu.my) Khong Teng Keen (edwinkhong89@gmail.com) Mohanasuntharaam a/l Nadarajah (monn_mj@yahoo.com) Hafiz Yusri (hafizyusri@gmail.com) *Corresponding author kg) and free weight test $(40.73 \pm 22.03 \text{ kg})$, as well as when given 5-min rest for both machine weight test $(48.11 \pm 26.91 \text{ kg})$ and free weight test $(42.00 \pm 24.67 \text{ kg})$, compared to the 1-min rest group for both machine weight test $(41.30 \pm 24.31 \text{ kg})$ and free weight test $(37.11 \pm 22.06 \text{ kg})$, for both gender. There was no significant difference between 3-min and 5-min rest periods for both types of weights. There was also no significant difference between the rest periods needed for both gender in both types of weights. Three-min rest interval is

ISSN: 0128-7702 e-ISSN: 2231-8534 enough for sedentary people irrespective of gender for 1-RM strength assessment on either machine weight bench press or free weight.

Keywords: Bench press, free weight, machine weight, rest interval, 1-RM

INTRODUCTION

Strength is described as the ability of muscle to exert force by the American College of Sports Medicine (Garber et al., 2011). Strength is one of the health-related fitness component, and a good strength profile may improve or maintain ability to perform daily activities, bone mass, musculotendinous integrity, fat-free mass (FFM), resting metabolic rate (RMR), and glucose tolerance, among others (Garber et al., 2011). There are various strength measuring tests, and the 1-Repetition Maximum (1-RM) test is one of the most commonly used test to quantify the level of strength, assess strength imbalances, and to evaluate training programmes by trainers, health and fitness professionals and rehabilitation specialists (Braith et al., 1993). Generally, the 1-RM is defined as the greatest resistance that can be moved through the full range of motion in a controlled manner with a good posture and is an indication of one's strength level. Early research on 1-RM testing dates to 1955 and has since been developed to be a reliable assessment of maximal strength (Hoeger et al., 1990). Basically, few maximal trials are carried out and the maximal weight achieved is considered as 1-RM strength. However,

there are different rest times between maximal trials recommended by various guidelines. The objective of this study was twofold: to determine which resting interval between the 1-RM trials is the most suitable for the sedentary people for machine and free weights; and to investigate whether there was a difference in optimal recovery time between male and female.

Literature Review

Currently, the guidelines by ACSM (2005) recommends 3-5 minutes of resting interval between trials, while the National Strength & Conditioning Association recommends 2-4 minutes of resting interval, and Adams (2009) Exercise Physiology Lab Protocol recommends 2-7 minutes of resting interval. Different resting intervals may affect the muscle's capability to produce maximum force, as acute neuromuscular fatigue recovery is affected by several factors such as recovery of motoneuronal pool, presynaptic inhibition, changes in neuromodulators hormones, cross-bridge effects, and excitation-contraction coupling failure, which takes different amount of time to recover and is variable within individuals (Carroll et al., 2017). Several researches have been carried out to determine an optimal rest interval between the 1-RM trials, and it has been suggested that 1-minute is enough for those with weight training experience to produce maximal force through 1-RM bench press test, as most of the participants are able to lift 2 consecutive 1-RM load with just a minute rest (Matuszak et al., 2003; Weir et al., 1994). However, similar data on untrained, inexperienced sedentary population is lacking. It is vital for testers to prescribe the right resting interval in order to get the most accurate 1-RM.

There might be a need to establish different rest interval for sedentary males and females, as several studies found that recovery speed and pattern are different in male and female. Hakkinen (1993) found that acute recovery from fatigue was slower in male compared to female after a maximal relative intensity exercise (1-RM) was performed; and in a later study Hakkinen (1994) found that even in near-maximal, high-intensity, low-repetition exercises, the strength recovery patterns in male was slower than females, and this was not only due to acute fatigue in neuromuscular system caused by higher accumulation of blood lactate concentration in males (15.0 \pm 4.0 mmol) compared to female (6.0 mmol \pm 1.8 mmol), but also due to the decrease in the voluntary neural activation of the exercised muscles. Other reasons presented include lower muscle fibre cross-section area in female compared to male (60-80 %

relative to male), and lower blood androgen level in females which lead to female developing smaller muscles than males (Folland & Williams, 2007).

MATERIAL AND METHODS

Sedentary participants were randomly recruited from the University of Malaya's students. The participants' anthropometric information is shown in Table 1. The definition of sedentary in this study is: not participating in at least 30 min of moderate intensity physical activity on at least three days of the week for at least three months. The participants were selected based on the ACSM Pre-participation Health Screening and Risk Stratifications questionnaire. Each participant signed a written consent form prior to participation. In random order as shown in Table 2, each participant underwent six 1-RM test, 3 each for bench press machine (Nautilus, USA) 1-RM test and free weight (barbell and weight plates, Nautilus, USA) 1-RM test; with resting interval of 1, 3, and 5 minutes between trials.

Table 1

Gender Number Age Weight (kg) Height (m) Body mass index (kg / m^2) Male 15 20.94 ± 1.44 $68.19 \pm 12.19*$ $1.72 \pm 0.06*$ $22.88 \pm 4.06*$ Female 15 22.53 ± 0.83 57.13 ± 11.08 1.59 ± 0.05 22.20 ± 3.84 All 30 21.65 ± 1.38 62.55 ± 12.84 1.66 ± 0.08 22.42 ± 3.89

Mean age, body weight, and body mass index of participants (Data are expressed as Mean \pm S.D)

The mean BMI of all participants $(22.42 \pm 3.89 \text{ kg/m}^2)$ are within the normal range $(18.5 - 25.0 \text{ kg/m}^2)$. *Significantly higher than female.

Overall Design

into 3 groups with different testing schedule by simple random sampling:

The participants were grouped randomly

Table 2

Sequence of rest intervals for each group

| | Rest interval be | etween 1-RM trials | |
|---------|------------------|--------------------|----------|
| Group 1 | 1-minute | 3-minute | 5-minute |
| Group 2 | 3-minute | 1-minute | 5-minute |
| Group 3 | 5-minute | 3-minute | 1-minute |

The 1-RM protocol was as follow, after participants did a 10-minute slow jogging as warm-up:

- As the final preparatory step, the performer loosened up and stretched by lifting one set of 8 repetitions at 50% of perceived 1-RM followed by a 1-minute rest; then performed another set of 5 repetitions with perceived 70% of 1-RM followed by another 1-minute rest.
- 2. With the participants lying supine on the bench and both feet on the floor, and hands shoulder width apart with palms up against the bar, the participants lifted the resistance with arms fully extended, then lowers the bar to chest and pushed it back up until the arms were locked. One full cycle of these movements is considered as 1 repetition.
- 3. In the case of free weight test, two testers were placed at each side of the participant or one tester behind the participant's pronated hands spaced about shoulder width apart and at chest level.

- The participant attempted a single lift at a load that was perceived as close (95%) to the perceived 1-RM. The load was recorded to the scoring sheet.
- 5. When the participant felt that the previous load was close to actual 1-RM load, 2.5 kg increments was added to the prior load; when the participant felt that the prior estimate of 95% of 1-RM was considerably off from actual 1-RM, then 5 kg increments was added.
- The participants rested (for 1, 3, and 5 minute, according to group schedule) before the next 1-RM trial.
- 7. Steps v to vi were repeated until the participant was unable to lift the weight. When this occurred, the participant rested. A 2.5 kg load was subtracted from the load and the participants attempted 1-RM. This weight was recorded as the 1-RM of the participants.

The results were analysed using the IBM SPSS Statistics 21 software (IBM,

USA). Independent *t*-Test was used to calculate the significance of differences among 2 data, where the value of (p < 0.05) is considered significant. The One-Way Anova Test was used to calculate the differences among more than 2 data, with the value of (p < 0.05) considered significant. The correlation among data was calculated, with the value of (r > 0.5) shows that 2 parameters are related to each other while the value of (r > 0.75) shows that the 2 parameters are strongly related.

RESULTS

In both free weight and machine weights 1-RM tests, results following 3 minutes rest

Hachine Weights 1-RM Result

Figure 1. The mean 1-RM results obtained from bench press machine for all participants. *significantly higher than 1 min.



Figure 3. The mean machine weight 1-RM results for male and female participants.

interval and 5 minutes rest interval were significantly higher (p < 0.05) than that obtained after 1-minute rest interval; with no differences between 3 and 5 minutes rest interval (Figures 1 and 2).

Meanwhile, while comparing results between male and females, the male participants produced significantly higher 1-RM values. In both gender, 3 minutes of rest interval produced better results compared to 1 minute rest. There were no differences in 1-RM results following 3 and 5 minutes rest intervals (Figures 3 and Figure 4).



Figure 2. The mean 1-RM results obtained from free weight bench press for all participants. *significantly higher than 1 min.



Figure 4. The mean free weight 1-RM results for male and female participants.

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DISCUSSION

The results show that 3 minutes rest interval is optimal for both free weight and machine weights 1-RM tests. This is consistent with past studies that state that longer (2 to 3 minutes) rest interval allows for significantly greater strength production than shorter (30 to 90 seconds) rest interval (Willardson & Burkett, 2008; De Salles et al., 2009). In contrast to how 1 minute rest interval is enough for weight trained and experienced populations to produce maximal force during 1-RM attempt (Weir et al., 1994; Matuszak et al., 2003), present study found that the sedentary population would need more than 1-minute rest interval, with 3 minutes rest allowing for best results.

The main reason cited for the need of longer rest-interval needed to produce maximum strength include, but not limited to, is to provide enough time to replenish phosphocreatine (PC) in worked muscles, as the ATP-PC system is the main energy system providing energy during an 1-RM attempt which typically last less than 5-second (De Salles et al., 2009). Another reason cited is that the participants may feel psychologically safer and have more confidence to produce maximal force with longer rest interval, stimulating the neuromuscular system to produce full effort and vice-versa, as short resting interval may lead to the participants feeling psychologically unsafe and as a result the neuromuscular system is not stimulated to exert maximum effort (Matuszak et al., 2003). There are, however, studies which asserted that 3 minutes rest interval between maximum force production efforts could impair maximal force production capability, resulting in a reduced 1-RM (Matuszak et al., 2003; Willardson & Burkett, 2008). One reason cited for the reduction in maximal force is the accumulation of lactic acid in muscles after long period (5-minute) of inactivity, as well as the muscle switching to resting mode (Matuszak et al., 2003). Participants for both said study was, however, recreationally weight-trained people, and the lactic acid profile may differ from the participants of present study who are all sedentary. Future study may include analysing changes in blood lactic acid level to investigate this phenomenon.

Another finding from the present study is that both gender produced the highest 1-RM results with 3 minutes rest interval between 1-RM attempts, with no significant differences in results obtained between the 3-minute and 5-minute rest intervals protocol. This result contradicts with past study which found that females had faster acute muscular recovery allowing them to produce maximal strength with less rest interval compared to males (Hakkinen, 1993). Even in sub-maximal force production, males recover slower than females (Hakkinen, 1994); males also have slower HR recovery following submaximal bench press exercise to exhaustion compared to females (Vieira et al., 2010). However, none of those studies showed the difference in studies time needed to fully recover maximal strength producing capability in males and females. In our study, the rest interval between 1-RM trials chosen was 1 minute, 3 minutes, and 5 minutes. A 3-minutes rest interval is sufficient for our participants of both gender to recover their maximum force production capability. Perhaps future study should include neurophysiological measures which will provide information on the adaptations that take place during the contraction during the 1-RM trials.

CONCLUSION

In conclusion, 3 and 5-minute rest intervals allow greater maximum force production for a 1-RM test protocol either using a machine weight or free weight. The results suggest that a rest period of 3-minute in between 1-RM attempt is recommended as the optimal rest period for both sedentary male and female to test their maximum strength, without the need to spend extra rest time that does not benefit to test results.

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Effects of Barefoot and Shod Running Training on Running Performances among Recreational Runners

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ABSTRACT

The running phenomenom has gained popularity over the past decades in Malaysia. However, running with shod or barefoot is still a debatable topic among runners and researchers. As such, this study investigated the effects of running with shod or barefoot on the predicted VO_{2 max} and ground reaction force (GRF). Twenty subjects (7 males and 3 females in each of the group) with no barefoot experience (EG, AGE: 20.1 ± 2.1 years, Running Experience: 2.6 ± 1.2 years and CG, AGE: 20.7 ± 1.7 years, Running Experience: 3.0 ± 1.3 years running experience) participated in this study. Predicted VO_{2 max} was calculated from 2.4 km run test while GRF for left leg (LL) and right leg (RL) were obtained from force plate analyses. Subjects were divided into 2 groups which were experimental (EG-barefoot) and control (CG-shod) groups based on the pre-test results. Both groups completed 6-weeks of intervention programme with twice a week of running training

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ISSN: 0128-7702 e-ISSN: 2231-8534 adapted from Mullen et al. (2014) at outdoor running track. The study found significant improvement in VO₂ of EG as compared to insignificant improvement in CG and revealed a greater reduction in the GRF for BF compared to shod runners. Results showed that EG improved significantly in the VO_{2 max} during post-test as in compared to pre-test (42.9 ± 7.5 vs. 40.7 ± 7.4 ml.kg⁻¹ min⁻¹; p=0.09). However, no significant difference was found in GRF between pre and post-tests in EG (LL: 1380.3 ± 271.8 N vs. 1340.4 ± 177.0 N, p=0.59 & RL: 1389.1 \pm 313.2N vs. 1326.3 \pm 218.7 N, p = 0.43). In CG, no significant changes were found in VO_{2max} and GRF (p>0.05) between pre-and post-tests. Even though the results of GRF did not show significant improvement in both groups, ~ 3.5% of slight decrement in GRF was found in EG. We speculate GRF can be reduced further with the increase of training volume. Thus, barefoot running training can be a tool to improve running performance in recreational runners.

Keywords: Barefoot running, foot strike pattern, ground reaction force, running performance

INTRODUCTION

Running has become more popular over the past decades in Malaysia. Running is considered as the most important recreational activity (De Wit et al., 2000) and is one of the most popular and widely practiced sports worldwide (Statista, 2018). Running's increased popularity worldwide is due to its high accessibility and low cost (Sun et al., 2018). In the USA alone, the popularity was reflected in almost 60 million people jogging in 2017 (Statista, 2018). Similarly, the healthy recreational running industry was reported to be thriving in the U.S as nearly 18.3 million people participated in the road races in 2017 ("U.S. Road Race", 2018). While many people enjoy running as a recreational activity or to maintain their fitness level, some others participate in competitive running. Running provides numerous physiological and psychological health benefits. The benefits include improved cardiovascular health (Williams, 2009a), decreased risk of stroke (Williams, 2009b) and hypertension (Mota et al., 2009), increased bone mass (Drysdale et al., 2007; Wilks et al., 2009) and psychological benefits such as decreased depression and a positive effect on mood state (Doyne et al., 1987; Schneider et al., 2009).

Running statistics are said to be influenced by footwear manufacturers in recent times. Running enthusiasts were attracted toward shoes that offer comfort, superior shock absorbent cushioning, motion control or stability, which provide a smooth and efficient running motion. This inclination is supported by the billions of dollars in revenue for the shoe industry in 2018 with Nike leading the pack with 22.27 billion (11.52 billion in 2010), Adidas achieved 12.78 billion (7.14 billion in 2010) and Puma reaped 2.5 billion (1.89 billion in 2010) (Statista, 2018). Even though continuous research and advanced technology had produced numerous types of good performance running shoes, the overall running injury rates have not been reduced. In a 2017 research, Running USA surveyed about 6,800 runners and reported that 75% of the respondents had had a running-related injury in the past 12 months, 50% had had their training curtailed for more than 4 days due to the injury. In fact, earlier research data had reported a prevalence of runningrelated injuries to range between 50% and 79% per year (Altman & Davis, 2012; Buist et al., 2010; Ferber et al., 2009; Fields et al., 2010; Kaplan, 2015; Taunton et al., 2002; Van Gent et al., 2007).

The persistent high rate of running injury despite advanced shoe technology (Davis, 2014; Rixe et al., 2012) has prompted Americans search for other ways to experience the benefits of running. Thus, barefoot (BF) running form has been suggested as a potential mechanism to reduce running injuries (Lieberman, 2012). Previously, McNair and Marshall (1994) suggested that BF was associated with kinetic and kinematic changes which resulted in decreased stride length and a more plantarflexed position at ground contact, that consequently helped prevent injury. Similarly, in examining the impact acceleration of BF and shod running, Thompson et al. (2016) revealed that there were significant differences in impact peak magnitude between BF and shod runners. In addition, in an online survey of 509 runners with some BF running experience conducted by Hryvniak et al. (2014), it was reported that 64% of them experienced no new injuries after starting BF running and 69% of them was free of previous injuries after starting BF running. This was echoed by Tam et al. (2014) that claimed BF running had become a popular research topic and gained significant attention due to its alleged benefits for runners of all levels. These benefits include the potential for reduced injury risk, and more economical running. In reviewing 96 relevant articles on the benefits of BF running, Kaplan (2015) reported differences in gait and other parameters between BF and shoe running and concluded that barefoot runners had fewer injuries, and better running performance. Similar findings were also revealed in the earlier review by Jenkins and Cauthon (2011) which stated that BF runners had fewer injuries and had better performance.

In terms of running economy (RE), BF runners who often are forefoot lander (Larson et al., 2011; Lieberman et al., 2015) as compared to about 90% shod runners who typically experience rear foot landing (Hasegawa et al., 2007; Lieberman et al., 2010; Onwaree, 2014), have better RE. Heel striking shod runners create braking forces which would generate more resultant vertical force instead of horizontal force during each running stride while running (Gisela et al., 2016; Mullen et al., 2014; Perkins et al., 2014; Tam et al., 2016). Consequently, the braking forces would increase the demands of energy expenditure and also reduce the speed of moving forward that induce poor RE (Marc, 2003). Conversely, BF running promotes forefoot landing that reduce the braking forces with the slight forward lean of the body which could convert the reaction force bounce forward rather than vertical direction. Without the braking force, running economy could be improved by 1 to 3% with forefoot landing pattern (Owen, 2013).

Similarly, Hanson et al. (2011) when investigating the oxygen cost of running BF versus running shod on the treadmill as well as over ground on 10 healthy recreational runners, reported that VO_2 while running shod was 5.7% and 2.0% higher than

running BF on over ground and treadmill respectively. The huge over ground VO₂ increase might be explained using the Divert et al. (2008) rationale that there was a rise in elastic energy storage during barefoot running when running over ground as compared to running on the treadmill. In a meta-analysis conducted by Cheung and Ngai (2016) in 13 studies and on 168 runners, it was found that BF running was shown to be more economical than shod running, requiring less oxygen consumption when running. BF running claims to have the ability to enhance proprioception feedback which is able to perfect landing mechanism for lower limbs injury prevention and also enhance running economy that is linked to the natural efficient landing stride (Perkins et al., 2014). Furthermore, other researchers (Jason & Rodger, 2012; Hanson et al., 2011, Tam et al., 2016) also concurred that BF running is much more economical than running shod as BF running eliminated the additional weight of the running shoe and numerous uncomfortable feelings that restricted the movement of both feet. In addition, Tung et al. (2014) reported that shoe added weight on runners which consequently increased the rate of oxygen uptake, energy expenditure and the heart rate response and thus impairing running economy.

Even though different strike patterns (Fore Foot Strike [FFS] versus Rear Foot Strike [RFS]) have led to numerous hypotheses about their relative costs and benefits, many researchers found no difference in terms of RE between FFS and RFS (Cunningham et al., 2010; Gruber et al., 2013; Perl et al., 2012). Similarly, Shih et al. (2013) reported that being shod or BF made little difference to RE rather, a forefoot strike would improve RE in comparison to a heel-strike. FFS and some MFS landings differ from RFS landings in generating no observable impact peak in the vertical Ground Reaction Force (GRF) just after contact (Hreljac et al., 2000; Milner et al., 2006; Pohl et al., 2009). Similarly, the extensive experimental tests conducted by Lieberman et al. (2010) found that forefoot strike generates substantially lower impact forces than those observed for RFS. FFS runners experience no impact peak and lower loading rates of the GRF compared to RFS runners (Hamill et al., 2011; Lieberman, 2012; Lieberman et al., 2010; Squadrone & Gallozzi, 2009). Over the last decade, Cheung and Ngai (2016) observed that BF running or running in minimalist shoes was getting popular not only as a way to minimize the risk of overuse injuries, but also as a potential strategy to improve RE.

The benefits of shod running and BF running are still inconclusive with both sides of the divide claiming their methods are better in improving running economy and reducing foot injury. Despite the heavy debate, there was a lack of research in Malaysia about the effects of BF training on RE. Thus, the purpose of this study was to compare 6-week shod running and barefoot running effects on RE and GRF.

METHODS

Participants

Twenty subjects (14 males and 6 females) with no barefoot experience (EG: 20.1 ± 2.1 yrs, 2.6 ± 1.2 years running experience and CG: 20.7 ± 1.7 yrs; 3.0 ± 1.3 years running experience) participated in this study. This study was carried out at the Tunku Abdul Rahman University College Kuala Lumpur (TAR UC KL). Referencing Wilmore and Costill (2005), this study targeted a sample of recreational runners with average VO₂ max values of 44.9 ± 6.90 ml/kg/min for male and 34.2 ± 3.84 ml/kg/min for female, or able to complete 2.4 km run with the average timing of 12 ± 2 min for male and 16 ± 2 min for female.

Design of the Study

The design of the study involved pre-test, intervention, and post-test. The participants were divided into 2 groups (EG, n=10; CG, n=10). The CG performed the running training programme wearing modern running shoes of their choice and the EG performed the running training programme barefooted. Both groups underwent a similar intervention programme for 6 weeks. Pretest and post-test were conducted before and after the 6 weeks intervention duration. Both groups were tested using a 2.4 km run test and force-plate analysis for the pre-test and post-test. After pre-test, the subjects were ranked according to the total z-score based on the 2.4 km run test and force-plate analysis. Then, subjects were assigned into 2 groups using a systematic counter balancing method. The EG and CG were randomly determined using fishbowl method.

Training Programme

This 6-weeks running training programme (Table 1) was adapted from Tam et al. (2016). The programme applied the principle of progressive overload. EG and CG applied the same 6-week training programme. The EG ran barefooted and the CG ran with running shoes. The intervention programme was conducted 2 times per week. The subjects were not briefed in terms of foot strike pattern and were instructed to run in the way that was most comfortable to them.

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Six-week barefoot running training program for Control Group and Experimental Group

| - | - | | | - | |
|------------|----|----------------|----|---------|-------|
| Group/Test | N | $Mean \pm SD$ | Df | t-value | Sig. |
| Pre-test | | | | | |
| EG | 10 | 40.72 ± 7.41 | 10 | 0.294 | 0.402 |
| CG | 10 | 42.06 ± 8.12 | 18 | 0.384 | 0.493 |
| | | | | | |
| Post-test | | | | | |
| EG | 10 | 42.85 ± 7.49 | 19 | 0.284 | 0.816 |
| CG | 10 | 44.05 ± 7.91 | 10 | 0.304 | 0.010 |

*The mean difference is significant at the 0.05 level

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Procedure

The Physical Activity Readiness Questionnaire (PAR-Q) form was prepared for all the subjects. Subjects filled-up the PAR-Q form and returned them to the researcher. Only subjects without any medical conditions were accepted for the study. Once accepted, the subjects were given a background information form to fill up. Background data such as age, body weight, height, leg length, running experience and 10 km best time were collected. Consent forms were distributed to all the subjects. Prior to signing the form, a briefing was provided regarding the research procedure, possible benefits and hazards during training, and confidentiality of the collected data. The consent form was signed and returned to researcher after the briefing session.

Before the pre-test, subjects underwent a short briefing on the test protocol to ensure that all subjects were familiar with the tests. Subjects performed a standardized warmup (Jumping Jack, 10 repetitions; Forward Lunge, 10 repetitions; and Mountain Climbers, 10 repetitions) before running on the track. Subsequently, subjects ran on the force-plate with self-selected pace to determine the ground contact force for both legs separately.

2.4km Run Test (Burger, 1990; r = 0.92, pilot study = 0.86)

The test was performed on the measured 2-lane running track and were required to run for 2.4 km. Subjects started to run on the signal 'GO', and ran 2.4 km with their best efforts. The total time of completion was recorded by the researcher and it was used to calculate the predicted VO_2 max value. Estimation of the VO_2 max for 2.4 km formula was determined using the formula below.

$$VO2 \max\left(ml.\frac{kg}{min}\right) = 3.5 + [483/2.4km time(min)]$$

Force-plate Analysis (Sebastian, 2015; r = 0.96)

Subjects were asked to run with modern running shoe (CG) or barefooted (EG) with self-selected running pace on the force-plate (Bertec Force Plate - Columbus) embedded in the laboratory floor. The force-plate was used to measure the GRF. The GRF was recorded after the subjects ran through the force-plate. The subjects performed forceplate run 3 times for each leg (right and left) and the mean scores were used for further statistical analyses.

Data Analysis

Statistical analyses were performed using Statistics Package for Social Science (SPSS) Ver. 19. Means, standard deviations, minimums and maximums were calculated for predicted VO₂ max and GRF. The demographic data of the subjects such as gender, age and years of running experience were also reported. T-tests were used for comparative analyses. The level of significance was set at p < 0.05.

RESULTS

Comparing the Predicted VO₂ Max in the Pre-test and Post-test between CG and EG

The Independent T-test result in Table 2 showed that the pre-test t-value of 0.384 was not significant (p=0.493) at 0.05 significant level. This showed that EG and CG started equal in terms of VO₂ max.

Similarly, the post-test comparison between CG and EG also revealed a nonsignificant result. The results did not support the notion that BF running was better than shod running in improving VO_2 max.

Results in Table 3 and 4 indicated that the EG had increased significantly in the predicted VO₂ max by 5.23 % (from 40.72 to 42.85 ml/kg/min) when comparing pretest and post-test results. Similarly, the CG has also increased their predicted VO₂ max by 4.73 % (from 42.06 to 44.05 ml/kg/min).

Comparing the GRF (Ground Contact Force)(measured by FPA) in the pre-test between CG and EG

Data analyses in Table 5 and 6 showed insignificant results in both the pre-test and post-test ground contact force mean values between CG and EG. These results revealed that both groups were similar before intervention and had no superiority over each other after the intervention duration.

Table 2

A comparison on the running economy (predicted VO_2 max value by 2.4 km run) in the pre-test and post-test between CG and EG

| Group | N | Test | $Mean \pm SD$ | df | t-value | Sig. |
|-------|----|------|------------------|----|---------|-------|
| EG | 10 | Pre | 40.72 ± 7.41 | 9 | -3.288* | 0.009 |
| | | Post | 42.85 ± 7.49 | | | |
| CG | 10 | Pre | 42.06 ± 8.12 | 9 | -1.722 | 0.119 |
| | | Post | 44.05 ± 7.91 | | | |

*The mean difference is significant at the 0.05 level

Table 3

A comparison of the pre and post-test (predicted VO_2 max measured by 2.4km run) for CG and EG

| Group | Test | Mean | S.D. | Median | Min | Max | Percentage |
|------------|-----------------------------|-------|------|--------|-------|-------|------------|
| EG(n=10) | VO ₂ max Pre | 40.72 | 7.41 | 19.62 | 31.42 | 51.04 | 5 72 |
| EG (II-10) | VO ₂ max Post | 42.85 | 7.49 | 21.39 | 32.74 | 54.13 | 5.25 |
| CC(n=10) | VO ₂ max Pre | 42.06 | 8.12 | 19.60 | 31.63 | 51.23 | 4 72 |
| CO (II-10) | VO ₂ max Post | 44.05 | 7.91 | 21.07 | 32.79 | 53.86 | 4.75 |

*The mean difference is significant at the 0.05 level.

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| ^ | · ^ | • • | | | | |
|-----------|-------|-----|------------------------|----|---------|-------|
| Side | Group | Ν | $Mean \pm SD$ | df | t-value | Sig. |
| Pre-test | | | | | | |
| TT | EG | 10 | 1380.36 ± 271.79 | 19 | 0.080 | 0 884 |
| LL | CG | 10 | 1503.17 ± 283.31 | 10 | 0.989 | 0.004 |
| DI | EG | 10 | 1389.12 ± 313.21 | 10 | 0.825 | 0.502 |
| KL | CG | 10 | 1499.80 ± 286.25 | 10 | 0.823 | 0.393 |
| Post-test | | | | | | |
| LL | EG | 10 | 1340.397 ± 177.046 | 18 | 1.324 | 0.127 |
| | CG | 10 | 1477.964 ± 276.700 | | | |
| RL | EG | 10 | 1326.305 ± 218.665 | 18 | 1.522 | 0.258 |
| | CG | 10 | 1491.647 ± 265.086 | | | |
| | | | | | | |

| A comparison of in | mprovement of predicte | $d VO_2 max (2.4 km)$ | run test) for EG and C | G |
|--------------------|------------------------|-----------------------|------------------------|---|

*The mean difference is significant at the 0.05 level; Note: LL = left leg, RL = right leg

The pre-post mean scores comparison in in the mean LL and RL scores for each EG Table 5 has showed insignificant differences and CG.

Table 5

Table 4

A comparison on the running economy (ground contact force measured by FPA) in the pre-test and post-test between CG and EG

| Side | Group | Ν | Test | $Mean \pm SD$ | df | t-value | Sig. |
|------|-------|----|------|------------------------|----|---------|-------|
| | EG | 10 | Pre | 1380.361±271.790 | 9 | 0.558 | 0.590 |
| LL | | | Post | 1340.397 ± 177.046 | | | |
| | CG | 10 | Pre | 1503.169 ± 283.311 | 9 | 0.521 | 0.615 |
| | | | Post | 1477.964 ± 276.700 | | | |
| RL | EG | 10 | Pre | 1389.115 ± 313.208 | 9 | 0.820 | 0.433 |
| | | | Post | 1326.305 ± 218.665 | | | |
| | CG | 10 | Pre | 1499.797 ± 286.253 | 9 | 0.148 | 0.886 |
| | | | Post | 1491.647 ± 265.086 | | | |

*The mean difference is significant at the 0.05 level; Note: LL = left leg, RL = right leg

However, the force-plate analysis results in Table 6 showed that the left LL GRF for EG reduced by 2.9 % (from 1380.36 N to1340.40 N) while the RL also indicated a reduction of 4.52 % (from 1389.12 N to 1326.31 N). As for CG, the LL ground contact force indicated a decrease of 1.68 % (from 1503.17 N to 1477.96 N) while the RL a 0.54 % reduction (from 1499.80 N to 1491.65 N).

Effects of Barefoot and Shod Running Training on Running Performances

| Group | Test | Mean | S.D. | Median | Min | Max | (%) | |
|--------------|---------------|----------|---------|---------|----------|----------|-------|--|
| EG (n=10) | FPA Pre (LL) | 1380.361 | 271.790 | 777.158 | 1028.283 | 1805.441 | -2.9 | |
| | FPA Post(LL) | 1340.397 | 177.046 | 561.475 | 1078.227 | 1639.702 | | |
| | FPA Pre (RL) | 1389.115 | 313.208 | 822.347 | 1030.213 | 1852.560 | -4.52 | |
| | FPA Post (RL) | 1326.305 | 218.665 | 747.054 | 1062.489 | 1809.543 | | |
| CG (n=10) | FPA Pre (LL) | 1503.169 | 283.311 | 809.27 | 1098.444 | 1907.714 | 1 69 | |
| | FPA Post (LL) | 1477.964 | 276.700 | 844.140 | 1103.294 | 1947.434 | -1.08 | |
| | FPA Pre (RL) | 1499.797 | 286.253 | 853.599 | 1031.862 | 1885.461 | -0.54 | |
| | FPA Post (RL) | 1491.647 | 265.086 | 707.343 | 1179.125 | 1886.468 | | |

A comparison of the pre and post-test (ground contact force for LL & RL measured by FPA) for CG and EG.

*The mean difference is significant at the 0.05 level; Note: LL = left leg, RL = right leg

DISCUSSION

Table 6

This study compared the effects of BF and shod running on running economy in recreational runners. The experimental study was conducted on 20 recreational runners from TARUC KL.

Barefoot and Shod Running and Predicted VO₂ Max

This study revealed non-significant post-test results of the Predicted VO₂ max (p=0.816). This result supported Kalina et al. (2016) insignificant difference in Running Economy (RE)(BF 31.5 \pm 2.65 vs RS 30.21 \pm 2.91; p = 0.086) when studying 9 female athletes (age 21.1 \pm 1.79 years old) with no previous BF running experience. Similarly, in another study of 15 male runners (age 27.8 \pm 5.1 years old) with no BF running experience using 8-week progressive BF running training programme, Tam et al. (2015) found that oxygen cost of transport was not significantly different between runners running BF and those running with shod. In a study of 21 experienced runners comparing the oxygen cost and other variables between BF and shod running, Vincent et al. (2014) found no significant difference in the steady state VO₂ between the shod and barefoot conditions (39.4 \pm 4.7 ml/kg/min vs. 40 \pm 5.2 ml/kg/min, respectively). The total energy expended in the shod and BF conditions was 974 \pm 134 kJ and 979 \pm 142 kJ.

The results of the pre-post comparisons of this study showed significant increment of 5.23% in the VO₂ of EG (from 40.72 to 42.85 ml/kg/min) and insignificant increment in CG (4.73%; from 42.06 to 44.05 ml/kg/min). The result showed that BF running was 2.7% more economical as compared to shod running. This is similar to the findings of Hanson et al. (2011) where BF running was 3.8% more economical than running with shoes and the subjects with shoes had a 5.7% higher \dot{VO}_2 Max. The superior RE is quantified as the submaximal oxygen uptake, has been associated with a lower \dot{VO}_2 max in distance runners (Fletcher et al., 2009; Morgan & Daniels, 1994). Similarly, in a meta-analysis of 13 studies which included 168 runners, Cheung and Ngai (2016) found that BF running was more economic than shod running.

The advantage of BF running was reported in a study by Wilkinson, et al. (2015) on the performance of 13 runners with shod and BF on separate days on treadmill (6-min treadmill runs at an average speed of 12.5 km/hour. Average oxygen cost decreased in BF as compared to shod running (90% CI -11% to -3%). Earlier research (Burkett et al., 1985; Catlin & Dressendorfer, 1979) reported that running BF could reduce oxygen cost at any given running speed. Similar findings were also revealed in numerous studies comparing RE in BF and shod running where 5 out of eight studies have reported significant reductions in the oxygen cost (Burkett et al., 1985; Catlin & Dressendorfer, 1979; Divert et al., 2008; Hanson et al., 2011; Perl et al., 2012). Conversely, Franz et al. (2012) in examining the Metabolic Cost of Running Barefoot versus Shod (lightweight cushioned,~150g) involving 12 males with substantial BF running experience found insignificant difference in VO₂ in the two situations. In fact, shod running had 3-4% lower VO2 than BF running. This insignificant result agrees with numerous earlier studies (Burkett et al., 1985; Frederick et al., 1984; Squadrone & Gallozzi, 2009). According to Cavanagh and Williams (1982), the higher VO₂ in BF runners was probably due to the fact that they preferred shorter and faster strides as compared to the greater stride length in shod runners. In another study to determine if the use of a systematic BF running training programme would result in an improved RE and race performance, Baroody (2013) reported that a progressive, 10-week BF running training programme improved RE and running performance.

A review by Jenkins and Cauthon (2011) in the Journal of the American Podiatric Medical Association concluded that scientific evidence had not yet provided conclusive evidence to support or refute the advantages of BF running over traditional shod running, however; the review noted that BF running may be an acceptable method of training.

Barefoot Running Training Programme and Ground Reaction Force

Although numerous studies have focused on comparing shod running and BF running and their effects on VO_2 , the studies did not examine the effect of GRF. Thus, this study investigated the GRF of recreation runners. The results of this research revealed that there was greater reduction in the GRF for EG (barefoot runners) as compared to the CG (shod runners). The superiority in GRF for EG over CG was for both the left and right foot.

The results is supported by the findings of Lieberman et al. (2010). They performed kinematic and kinetic analyses on runners and found that barefoot runners strike the hard surface using forefoot as compared to shod runners which had plunged the ground using rearfoot. The forefoot strike generated smaller collision forces than rearfoot strike. The smaller force could be explained by a more plantarflexed foot at landing and more ankle compliance during impact thus decreasing the body effective mass of the body when contact was made with the ground.

In a systematic review of biomechanical differences between running BF and shod, Hall et al. (2013) reported moderate evidence that BF running was associated with reduced peak GRF, increased foot and ankle plantarflexion and increased knee flexion at ground contact compared with shod running. In addition, the review also revealed that BF running with forefoot strike pattern appeared to reduce loading rate while shod running with RF strike pattern had loading rate increased.

Another meta-analyses of kinematic variables on 16 studies by Almeida et al. (2015) reported significant differences between forefoot and rearfoot strikers for foot and knee angle at initial contact and knee flexion range of motion. A forefootstrike pattern resulted in a plantar-flexed ankle position and a more flexed knee position, compared to a dorsiflexed ankle position and a more extended knee position for the rearfoot strikers, at initial contact with the ground. In fact, rearfoot strikers had higher vertical loading rates compared to forefoot strikers.

Hasegawa et al. (2007) examined the strike pattern and the association between Ground Reaction Time (GRT) and finishing in half-marathon and reported a significant relationship between GRT and finishing in the race, and better position was achieved with shorter GRT. In addition, they revealed that a quarter of the competitors who were forefoot (FFS) and midfoot strikers (MFS) (187.4 ms) had shorter GRT than rear foot strikers (RFS) (199.8 ms). Similarly, in a study of 181 middle distance runners, Hayes and Caplan (2012) found both forefoot and midfoot strikers had shorter average GRT than rear foot strikers.

Numerous researchers (Cavanagh & Lafortune, 1980; Lieberman et al., 2010) have confirmed that FFS is characterized by a reduced impact peak for the GRF and RFS is characterized with a huge impact peak and an increased loading rate of the vertical GRF (Milner et al., 2006). Similarly, Lieberman et al. (2010) and Williams et al. (2000) revealed that FFS was associated with decreased vertical loading rate. In addition, in investigating the running gait of habitually unshod runners, Lieberman et al. (2010) reported that FFS did not generate high impact peaks caused by RFS.

In examining the combined effects of foot strike pattern, step rate and anterior trunk lean gait modifications on impact loading in 19 healthy runners, Huang et al. (2019) found that FFS combined with increased step rate had a lower impact loading rates as compared to RFS combined with anterior trunk lean. However, in reviewing 18 studies to evaluate biomechanical differences between running BF and shod, Hall et al. (2013) reported moderate evidence that BF running was associated with reduced peak GRF. In fact, their review indicated that barefoot FFS reduced loading rate as compared to RFS. Further, in investigating 12 physically active participants (7 females, 5 males) to determine the differences in GRFs between BF and shod running, Meredith et al. (2015) found that there was no significant difference between the peak impact force between BF (1245.03 +/- 545.0 N) and shod running (1331.8 +/- 567.4 N; p>0.05).

Thompson et al. (2016) studied 10 physically active and healthy runners running in 3 conditions (BF and BF while heel striking, shod). They reported that both BF and shod runners showed decreased impact peak magnitude. In addition, they revealed that BF runners had decreased impact peak magnitude as compared to increased impact peak magnitude in shod runners.

In numerous other previous research (Cavanagh & Lafortune, 1980; Laughton et al., 2003; Lieberman et al., 2010; Nilsson & Thorstensson, 1989), it was suggested that FFS was better than RFS in reducing the potential of injury risk when running. The vertical component of GRF during the early stance phase, and the loading rate of that force, were smaller for FFS and MFS than for RFS. This is supported by Kulmala et al. (2013) who examined the difference in limb loading profile among 19 female athletes between RFS and FFS runners. FFS runners exhibited lower patellofemoral contact force and stress as compared to RFS runners.

The result of this study revealed that right foot (RL) reduced GRF larger (4.5%) as compared to the left foot (LF) (2.9%) in the EG. While CG reported greater reduction in GRF in the LL (1.68%) as compared to RL (0.54%). Over all, EG has greater reduction in GRF for both legs as compared to CG. The results are supported by Tam et al. (2016) where a similar BF running training programme for 8 weeks with 3 sessions per week was applied. Tam et al. (2016) reported GRF was reduced for both BF and shod running subjects. The loading rate changes (p < 0.001) for BF and shod runners was 12.9 kg/s and 9.8 kg/s respectively. However, it was not reported the differences between RF and LF. Similarly, other researchers (Divert et al., 2008; Squadrome & Gallozzi, 2009) also reported that there was decrement in GRF for barefoot strikers but which legs had higher percentage of reduction was not reported.

CONCLUSION

The present study has shown significant improvement in VO₂ of EG as compared to insignificant improvement in CG. Our results also revealed a greater reduction in the GRF for BF compared to shod runners, both in the right and left foot. BF running was 2.7% more economical as compared to shod running, suggesting a possible ergogenic benefit of barefoot compared to shod running. The improvement in VO₂ of EG appears to be related to the removed shoe mass in barefoot runners which helped in reducing the mean oxygen cost of steadystate running. BF running is associated with some alterations to gait which runners strategized to avoid impact (plantar-sensory feedback hypothesis) and this is associated with oxygen cost reduction. Further research

is needed to examine foot strike pattern and speed of striking of BF runners.

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Effects of Six Weeks Swiss Ball Training on Balance and Agility of College Soccer Players

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ABSTRACT

The aim of this study was to determine the effects of six weeks of Swiss Ball Training (SBT) on balance and agility of college soccer players. A total of 19 male soccer players (AGE = 20 ± 1.73 years, BW = 63.42 ± 9.95 kg., H = 172.11 ± 4.45 cm) participated in this study. The subjects were assigned randomly into the control group [CG] (n = 10) and experimental group [EG] (n = 9). The two groups had similar 6-week soccer programme while SBT was given to the EG twice a week, 60 minutes per session, as additional programme. The subjects were tested on static balance using the Standing Stork Test ($\alpha = 0.969$), dynamic balance using the Four Step Square Test ($\alpha = 0.818$), and agility using the Illinois Agility Test ($\alpha = 0.965$). The two groups were equivalent on the pre-test for the three variables revealing insignificant results. Similarly, the post-test results showed insignificant difference in the three variables. However, pre-test and post-test comparison revealed that

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E-mail addresses: tiewka@tarc.edu.my (Kee Aun Tiew) weeeh@tarc.edu.my (Eng Hoe Wee) *Corresponding author there was significant improvement in static balance, dynamic balance and in agility for the EG. In conclusion, there is insufficient evidence to support that the SBT could enhance performance in balance and agility of college players.

Keywords: Agility, balance, core stabilization, swiss ball training

INTRODUCTION

Soccer is a physically demanding sport which requires players to perform highintensity movements such as short and

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explosive sprints, jumps and repeatedly change of directions during a 90 min match (Bangsbo et al., 2006; Krustrup et al., 2005; Meckel et al., 2009; Reilly et al., 2000a; Stolen et al., 2005). And those actions require overall strength and power production, speed, agility, balance, flexibility, stability, and the adequate level of endurance (Bloomfield et al., 2007; Jovanovic et al., 2011; Krustrup et al., 2005). Often the high-intensity movements such as jumps, runs, and sudden change of directions executed by soccer players would affect the competition results (Bangsbo et al., 2006; Di Salvo et al., 2009; Luhtanen, 1994; Reilly et al., 2000a). Even though these high speed movements constitute only about 10-15% of the total distance covered by soccer players, these activities usually involve movements during crucial situations that result in better ball possessions and better scoring performance (Di Salvo et al., 2009; Reilly et al., 2000a). Previously, Sheppard and Young (2006) used time and motion analysis to prove that the ability to sprint and to change direction while moving were factors which decisively affected sport performance. Those physical attributes were associated with core stability training (CST).

During a soccer game, players performed sprinting and changed direction swiftly according to situation (Salaj & Markovic, 2011; Wong et al., 2012). Soccer players have been reported to change direction during game 1,200-1,400 times every 2-4 seconds (Bangsbo, 1992; Davids et al., 2000; Verheijen, 1997). In addition, it is essential for a player to change directions quickly while running (Salaj & Markovic, 2011; Wong et al., 2012). Consequently, in soccer, agility is of central importance for the optimal performance (Harman et al., 1990). Agility is important either to match or outclass other soccer opponents individually. Agile soccer players can move swiftly to take advantage of the space. In offensive mode, agile soccer players can lose their markers by changing direction quickly and in defensive mode, players can keep up with movement of the player they are tasked to mark. In a longitudinal study of young superior soccer players, Mirkov et al. (2010) observed the potential of agility and coordination in achieving success in soccer, thus should be used for early selection. In fact, earlier studies on soccer had reported that about 11% of the total distance covered during a game was associated with agility with speed. This has increased soccer ball possessions and enhanced goals scoring chances (Little & Williams, 2005; Reilly et al., 2000a; Reilly et al., 2000b).

Agility brought success to soccer (Pojskic et al., 2018) through the integration of neuromuscular coordination, reaction time, speed, strength, and balance. It is considered as a crucial element in soccer performance (Trecroci et al., 2018). It helps soccer players increase their ability to maintain balance, speed, strength and coordination. Soccer is played at great speed and at those speeds, twists and turns cause players to lose balance. However, agility helps players to regain their body balance; agile players could maintain and control proper body positions while moving quickly in various directions (Little & Williams, 2005; Sporis et al., 2010). Furthermore, previous research in soccer has used dynamic balance performance to differentiate levels of competition (Bressel et al., 2007; Butler et al., 2012; Davlin, 2004). The lack of dynamic balance among soccer players can increase the potential of injury risk (Butler et al., 2012). According to Sporis et al. (2010), the improvement in agility can be solicited through the improvement of balance. Research investigations suggest that in addition to muscle strength, power, and speed (Meylan et al., 2009), balance is an important influencing factor of Change of Direction (COD), specifically for soccer players (Sporis et al., 2011). In fact, evidence from cross-sectional studies indicates significant associations between muscle strength and power (Delextrat & Cohen, 2009: Sheppard & Young, 2006), balance (Sekulic et al., 2013), speed (Nimphius et al., 2010) and agility.

In examining young soccer players, Mirkov et al. (2008) reported that the notable advantage of the players appeared to be movement agility. The advantage can be due to efficiency in achieving and maintaining balance while moving. Indeed, the ability to maintain appropriate postural adjustments resulted in balance being maintained which enables COD to be performed frequently (Hammami et al., 2017). Further, static and dynamic balance can be affected by the efficiency of neuromuscular control adaptations, which in turn affects high speed movement among athletes (Jones et al., 2009).

Previous researches (Afyon et al., 2017; Bashir et al., 2018; Kibler et al., 2006) reported that the core training enhanced the core region which played crucial role in stabilization and force generation in sports activities. Core stability (CS) is the ability to control trunk position and motion. CS facilitates the transfer, and control of forces to and from the terminal segments in order to generate optimal forces, during functional activities (Kibler et al., 2006). In addition, CS maintainsfunctional stability in a neutral position and assists in the generation and transfer of energy from the trunk to the extremities (Akuthota & Nadler, 2004; Shirey et al., 2012).

CST is conducted using numerous exercises done with the individual's own body weight which aimed at strengthen the lumbopelvic muscles and deep muscles that keep the spine balanced (Atan et al., 2013). Core exercises train muscles that control and stabilize the movements of the abdomen, waist, and hip of individuals including soccer players (Aksen-Cengizhan et al., 2018). It is believed that core muscle development is imperative in many functional and athletic activities, because core muscle recruitment enhances CS and helps provide proximal stability to facilitate distal mobility (Escamilla et al., 2010). One of the ways to achieve core muscle training effects is through SBT.

The use of SBT for core muscle development has been getting tremendous attention since its inception in the 1960s (Cosio-Lima et al., 2003) and core training has become a major element of sport

training plans (Riewald, 2003). Swiss ball exercises provide a wide range of activation of the core musculature (Escamilla et al., 2010) which helps increases individual functional capacity and improves athletic skills (Schilling et al., 2013) as well as improves fitness in sports such as soccer and parkour (Shelvam & Sekhon, 2014). Several researchers have advocated the effectiveness of Swiss ball exercises in improving CS (Borghuis et al., 2008; Santana, 2011) as the unstable surfaces provided by a Swiss ball activates the core muscles considerably in improving trunk stability and balance. Similarly, Srivastav et al. (2016) reported the superiority of SBT over mat surface in improving core stability. CS creates several advantages for neural function (Borghuis et al., 2008) including improving neural recruitment and synchronization of motor units which facilitate rapid nervous system activation while lowering neural inhibitory reflexes. CS exercises may generate more force through influencing the timing pattern of the muscle activation (Borghuis et al., 2008; Kibler et al., 2006), and therefore significantly improved coordinated movement performance. In a study of the effects of SBT on the agility of 30 netball players (19-24 years) for 8 weeks, Shelvam and Sekhon (2014) found that the mean agility score of the EG was significantly different from that of CG. The result was supported by Cosio-Lima et al. (2003), Willardson (2007) and Stanton et al. (2004). Other researchers concur that from a sports performance perspective, greater core stability provides a foundation for

greater force production in the upper and lower extremities (Mccurdy et al., 2005; Willardson, 2007).

In examining the effects of short-term SBT on CS and running economy among 18 young male runners, Stanton et al. (2004) found the EG which performed 2 SBT sessions per week for 6 weeks improved CS significantly. Similarly, Sundaram (2016) in a study of basketball players revealed that Swiss ball core exercises were more beneficial than traditional core exercises in improving basketball performance. Other researchers such as Collins (2007) and Prentice (2011) concurred that SBT which trained core and stabilizing muscles played a vital role in body stability and maintaining equilibrium.

The use of SBT which focused on unstable surfaces could be crucial in improving performance as athletes in several sports including soccer often perform on relatively unstable surfaces. Soccer players needed specific training as they ran, kicked ball, jumped and landed on uneven natural turf (Behm & Sale, 1993), SBT could closely mimic the demands of the soccer (Behm et al., 2010). This is supported by Prieske et al. (2015) emphasising that the combination of structured soccer training and CST on stable or unstable surfaces might successfully be applied to improve performance in youth soccer players.

Although SBT has been reported to enhanced physical fitness and sport performance, few studies are associated to soccer. SBT improved strength, endurance, flexibility, and balance in sedentary women

(Sekendiz et al., 2010) while it was effective in improving static and dynamic balance in university students (Yu et al., 2017). In sport, SBT improved agility in netball players (Shelvam & Sekhon, 2014), enhanced basketball performance (Sundaram, 2016) and running economy (Stanton et al., 2004). Previous research related to the effects of SBT on physical fitness in soccer has revealed that SBT has improved agility (Mirkov et al., 2008; Pojskic et al., 2018; Trecroci et al., 2018) and dynamic balance (Butler et al., 2012; Sekulic et al., 2013; Sporis et al., 2010; Sporis et al., 2011). Apparently, there were no other reports on physical fitness measurement involving SBT in soccer.

To date, there have been only two published studies reporting objectively measured physical fitness components using SBT and two using CST in Malaysia. Balakrishnan et al. (2016) found SBT reduced back pain and disability in individuals with non-specific low back pain while Sukalinggam et al. (2012) revealed that SBT enhanced strength in the back and abdominal muscles more in untrained females than males. CST was reported to improve dynamic balance in volleyball players (Sadeghia et al., 2013) and improved power, balance and leg strength in Malaysian rhythmic gymnasts (Nazari & Lim, 2019). Hence, to address the gap in knowledge, this study aimed to measure the effects of SBT on agility and balance of college soccer players.

METHODS

Participants

Twenty-two male college soccer players participated in this study. They were members of the same college team and were participating in soccer practice and games three times per week at the time of the investigation. The subjects were assigned into the EG (n = 11) or the CG (n = 11). Nineteen players completed the study (AGE $= 20 \pm 1.73$ years, BW $= 63.42 \pm 9.95$ kg, H = 172.11 ± 4.45 cm). All participants had been involved in soccer training regularly for an average of 5.1 years before the study. Three subjects dropped out (CG=1, EG=2) from this research due to inability to continue the study for 6 weeks. Data from the 19 players were used for final statistical analysis. Previous similar studies used 12 to 19 subjects, thus based on the sample sizes of those studies, the sample size of this study was considered adequate (Stanton et al., 2004 [N=18, CG=10, EG=8]; Myer et al., 2006 [N=19: CG=8, EG=11]; Cressey et al., 2007 [N=19: CG=10, EG=9]; Thomas et al., 2009 [N=12: EG=6, CG=6]). Prior to the commencement of this study, the subjects filled-up the Physical Activity Readiness Questionnaire (PAR-Q) to rule out participation contraindications. PAR-Q results showed that all the subjects were healthy and eligible to participate in this study. The subjects also signed the consent form after the briefing on the methods, procedures, benefits and potential risk. The Ethics Committee of Tunku Abdul Rahman University College approved this study.

Design of the Study

The design of this study was pre-testintervention-post-test. The subjects were assigned randomly into CG and EG after pre-tests on static balance using the Standing Stork Test (Johnson & Nelson, 1986), dynamic balance using the Four Step Square Test (Whitney et al., 2007), and agility using the Illinois Agility Test (Getchell, 1979). The assignment of subjects into the 2 groups were based on the computed total Z-scores of the 3 pre-tests. The systematic-counterbalancing method was used to assigned them into the 2 groups and the Fishbowl method was used to assign them into the CG and EG. The two groups underwent a similar 6-week soccer programme while supplementary SBT was administered to the EG twice a week, 60 minutes per session for the duration. Post-test was conducted for both groups after the end of the six weeks.

Procedures

This study involved three phases of pretesting, 6-week training/intervention, and post-testing. Pre-test was conducted before the 6-week training/intervention and posttest was carried out after the 6 weeks period. Familiarization session was held before the pre-test to ensure subjects understood the testing procedures. Participants performed the EG or CG programme thrice weekly (two hours per session) for 6 weeks after pre-testing. Intervention programmes for the EG were conducted by the researcher while the coach assisted in monitoring subjects' attendance. All subjects were instructed not to participate in other physical training other than the mandatory programmes for each group. After the 6-week period, similar 3 tests were conducted in the post-test.

Exercise Testing

Before the pre-test, a short briefing was provided to inform the subjects about the tests. A twenty minutes standardized warm up activities was conducted after the briefing. Activities done during the warm up included slow jogging and static stretching of the soccer programme. The testing session started with Standing Stork Test (Johnson & Nelson, 1986), followed by the Four Step Square Test (Whitney et al., 2007), and Illinois Agility (Getchell, 1979) in sequence. Prior to the pre-test, the Standing Stork Test and Four Step Square Test were pilot tested using Tunku Abdul Raham University College Sports and Exercise students (N= 31, 20.03 ± 1.8 years old) while Illinois Agility Test was verified in Malaysia by Heang et al. (2012).

Standing Stork Test (Johnson & Nelson, 1986; r=0.85-0.87, pilot = 0.969).



This test measured static balance. The subjects performed the test barefooted. The performer stood on the foot of the dominant leg, placed the other foot against the inside of the supporting knee, and placed the hands on the hips. On the signal "Go," the performer raised the heel of the dominant foot from the floor and attempted to maintain balance as long as possible The trial ended when the hands were moved from the hips, when the ball of the dominant leg moved from its original position, or when the heel touched the floor. Three trials were administered. Best time in seconds of the three trials performed was recorded.

Four Step Square Test (Whitney et al., 2007; r=0.86-0.96, pilot=0.818)



This test measured dynamic balance. The subject stood in square 1 facing forward. Upon instruction 'GO', the subject stepped as fast as possible in the clockwise direction into each square in the following sequence: 2, 3, 4, 1, then immediately moved counter clockwise from 4, 3, 2, 1. Best time in seconds of two trials was recorded.

Illinois Agility Test (Getchell, 1979; Raya et al., 2013, 0.65; Heang et al., 2012, 0.965) Subjects lied prone with hands pointed forward. On the 'Go' command the subject jumped up quickly and negotiates the course around the cones to the finish line. Subjects were given 3 minutes of rest between trials.



Average time in seconds in three trials was scored.

Training Programme

Training programmes were conducted three sessions weekly for 6 weeks. The Soccer Training Programme in Table 1 was for both the EG and CG. The SBT Programme in Table 2 was provided to the EG and was adapted from Stanton et al. (2004) and Goodman (1999).

Data Analysis

Research data were analysed using SPSS 23.0 software (IBM, USA). All basic data were presented as means, standard deviations and percentages. Background information such as age, body weight, height and soccer training experience were also reported. Independent t-tests were performed to determine if any significant differences existed between CG and EG before and after the 6 weeks study period. Paired sample t-tests were used to determine if significant differences existed between the pre-test and post-test mean scores for each group on the three dependent variables. The statistical significance was set at p < 0.05.

| Prog | țramme | | | | | | Tuesc | lay | | | | Th | ursday | | |
|---------|--------------------------|------------|----------|---------|---------|------|----------|------|------|---------|------|-------|---------|------|--------|
| | | | | | W1 | W2 | W3 | W4 | W5 | M6 V | V1 W | '2 W3 | W4 | W5 | W6 |
| Warı | dn-m | | | | 10 | 10 | 10 | 10 | FM | NT 1 | 0 F] | M FM | 10 | LN | NT |
| Rest | | | | | S | 5 | 5 | 5 | | 5 | | | 5 | | |
| Spec | ific Warm-up | | | | 20 | 10 | 10 | 10 | | 7 | 0 | | 10 | | |
| Rest | | | | | 5 | 5 | 5 | 5 | | 5 | | | 5 | | |
| Indiv | vidual attacks/defenc | es | | | 20 | ı | | | | 5 | 0 | | ı | | |
| Pass | drills | | | | ı | 20 | | | | ı | | | ı | | |
| Defe | nce Formation | | | | ı | ı | 1 | 20 | | I | | | ı | | |
| Rest | | | | | 5 | 5 | | 5 | | 5 | | | ı | | |
| Full | match simulation | | | | 55 | 65 | 65 | 55 | | 5 | 5 | | 90 | | |
| FM - | = Friendly Match | $NT = N_0$ | Training | 50 | | | | | | | | | | | |
| C oldor | ~ | | | | | | | | | | | | | | |
| I auto | | | | | | | | | | | | | | | |
| Six we | eks SBT programme | | | | | | | | | | | | | | |
| No | Exercise | Week | | | | Weel | ٤ 2 | | | | Week | 3 | | | |
| | | Sets | Reps | Time(s) | Rest(s) | Sets | Reps | Tim | e(s) | Rest(s) | Sets | Reps | Time(s) |) R. | est(s) |
| - | Balanced Sitting | 1 | | 60 | 30 | - | | 60 | | 30 | - | | 60 | 30 | |
| 2 | Elbow Bridge | 2 | | 25 | 15 | 7 | | 35 | | 15 | 2 | | 45 | 20 | - |
| Э | Side Bridge | 1 es | | 20 es | 10 | 2es | | 20es | | 10 | les | | 35es | 15 | ies |
| 4 | Forward Roll on Knees | 7 | 8 | | 09 | 7 | ∞ | | | 09 | 7 | 10 | | 60 | - |

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Table 1

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| Table 2 | 2 (Continued) | | | | | | | | | | | | |
|---------|--|------------|------|-----------|---------|--------|--------|----------|---------|------|------|---------|---------|
| No | Exercise | Wee | k 1 | | | [wee] | k 2 | | | Week | 3 | | |
| | | Sets | Reps | Time(s) | Rest(s) | Sets | Reps | Time(s) | Rest(s) | Sets | Reps | Time(s) | Rest(s) |
| 5 | Hands On Ball | 1 | | 30 | 15 | | | 40 | 20 | - | | 45 | 20 |
| 9 | Shoulder Bridge - both feet down | 5 | 8 | | 09 | 7 | 8 | | 60 | 7 | 10 | | 60 |
| | Shoulder Bridge - elbows down/one leg up | | | | | les | | 20es | 10 | 1es | | 30es | 15 |
| 8 | Supine Lateral Ro | 11 2 | 8es | | 60 | 7 | 8es | | 60 | 7 | 10es | | 60 |
| 6 | Alternating Superman | 7 | 8es | | 60 | 7 | 8es | | 60 | 7 | 10es | | 60 |
| 10 | Lunge | 2 | 8es | | 60 | 7 | 8es | | 60 | 7 | 10es | | 60 |
| 11 | Crunch | С | 30 | | 60 | | | | | б | 20 | | 60 |
| 12 | Heal Grab Crunch | | | | | 3 | 25 | | 09 | 2 | 20 | | 60 |
| 13 | Supine Russian Twist | 2 | 8es | | 60 | 7 | 8es | | 60 | 7 | 10es | | 60 |
| Table 2 | la. | | | | | | | | | | | | |
| Six wea | eks SBT programme. ((| Jontinued) | ~ | | | | | | | | | | |
| No | Exercise | Week 4 | | | | Week 5 | | | | Week | 9 | | |
| | | Sets | Reps | Time(s) I | Rest(s) | Sets] | Reps T | ime(s) | Rest(s) | Sets | Reps | Time(s) | Rest(s) |
| - | 4 Point Kneeling | 1 | | 60 | 30 | 1 | 9 | 0 | 30 | - | | 30 | 15 |
| 7 | 2 Point Kneeling | | | | | | | | | - | | 30 | 15 |
| ю | Side Bridge | 2es | | 30es | 5 | 2es | ξ | 5es/30es | 15 | 2es | | 40/25es | 30 |

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| | (Continued) |
|-----------|--------------|
| | T programme. |
| | SB |
| Table 2a. | Six weeks |

| No | Exercise | Week 4 | | | | Week : | | | | Week | 9 | | |
|----|---|--------|------|---------|---------|--------|------|---------|---------|------|------|---------|---------|
| | | Sets | Reps | Time(s) | Rest(s) | Sets | Reps | Time(s) | Rest(s) | Sets | Reps | Time(s) | Rest(s) |
| 4 | Forward Roll on Knees | 2 | 10 | | 60 | 3 | 8 | | 60 | 3 | 8 | | 60 |
| 5 | Shoulder Bridge – both feet down | 7 | 10 | | 60 | б | 8 | | 60 | б | 8 | | 60 |
| 9 | Hip Bridge – both feet down/one leg up | 1 | | 30/10es | 60 | 1 | | 30/20es | 60 | 1 | | 40/25es | 60 |
| 7 | Supine Lateral Roll | 2 | 10es | | 60 | 3 | 8es | | 60 | б | 8es | | 60 |
| ~ | Alternating Superman | 2 | 10es | | 60 | 3 | 8es | | 60 | 3 | 8es | | 60 |
| 6 | Lunge | 2 | 10es | | 60 | 3 | 8es | | 60 | 3 | 8es | | 60 |
| 10 | Pike | 2 | 5 | | 30 | 2 | 7 | | 30 | 1 | 10 | | 30 |
| 11 | Diagonal Crunch | 1 | 10es | | 60 | 1 | 15es | | 60 | | | | |
| 12 | Crunch+Hip Extension | | | | | | | | | 1 | 20 | | 09 |
| 13 | Supine Russian Twist | 2 | 10es | | 60 | 3 | 8es | | 60 | 3 | 8es | | 60 |

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RESULTS

Pre-test statistical analysis in Table 3 showed insignificant results confirming that EG and CG were equal in all the three parameters, before the study started. Similarly, post-test in Table 4 showed non-significant results for all the three parameters for both groups. In Table 5, The pre-post mean scores comparison of the three parameters for each group revealed higher improvement in EG for Standing Stork Test (76.4%), and greater improvement in dynamic balance (19.4%) and agility (1.5%) as compared to CG.

DISCUSSION

The study examined the effects of SBT on agility and balance of college soccer players. The post-test results in this research showed insignificant differences between EG and CG in Static Balance, Dynamic Balance and Agility mean scores. This has diminished the potential of SBT in affecting static balance, dynamic balance and agility within a short duration. This result partially supported Ozmen and Aydogmus's (2016) finding related to agility. In a study of the effects of Core Strength Training (twice a

Table 3

A comparison of pre-test mean scores static balance, dynamic balance and agility between CG and EG

| Test | Group | n | Mean±SD | t-value | Sig. |
|------|--------------|----|------------------|---------|------|
| SST | Control | 10 | 20.50±2.075 | 0.47 | 0.65 |
| | Experimental | 9 | 16.64±1.439 | | |
| FSST | Control | 10 | 4.09 ± 0.42 | 0.02 | 0.09 |
| | Experimental | 9 | 4.08±0.63 | 0.03 | 0.98 |
| IAT | Control | 10 | 17.48 ± 0.99 | 0.17 | 0.97 |
| | Experimental | 9 | 17.56±1.09 | -0.1/ | 0.87 |

* Significance level is set at p < 0.05

Note: SST = Standing Stork Test FSST = Four Step Square Test IAT = Illinois Agility Test.

Table 4

A comparison of post-test mean scores static balance, dynamic balance and agility between CG and EG

| - | | | | | |
|------|--------------|----|-------------|---------|------|
| Test | Group | n | Mean±SD | t-value | Sig. |
| SST | Control | 10 | 24.23±1.943 | -0.56 | 0.58 |
| | Experimental | 9 | 29.35±2.015 | | |
| FSST | Control | 10 | 3.46±0.42 | 0.81 | 0.43 |
| | Experimental | 9 | 3.30±0.44 | | |
| IAT | Control | 10 | 17.88±1.06 | 1.29 | 0.21 |
| | Experimental | 9 | 17.29±0.93 | | |
| | | | | | |

* Significance level is set at p < 0.05

Note: SST = Standing Stork Test FSST = Four Step Square Test IAT = Illinois Agility Test.

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| Test | Group | N | Test | Mean±SD | t-value | Sig. | % Improvement |
|------|--------------|----|------|------------------|---------|-------|---------------|
| SST | Control | 10 | Pre | 20.50±2.08 | -0.94 | 0.37 | 18.2% |
| | | | Post | 24.23±1.94 | | | |
| | Experimental | 9 | Pre | 16.64±1.44 | -2.75 | 0.03* | 76.4% |
| | | | Post | 29.35±2.02 | | | |
| FSST | Control | 10 | Pre | 4.09 ± 0.42 | 3.74 | 0.00* | 15.4% |
| | | | Post | 3.46 ± 0.42 | | | |
| | Experimental | 9 | Pre | 4.08 ± 0.63 | 6.87 | 0.00* | 19.4% |
| | | | Post | 3.30 ± 0.44 | | | |
| IAT | Control | 10 | Pre | 17.48 ± 0.99 | -1.92 | 0.09 | -2.4% |
| | | | Post | 17.88 ± 1.06 | | | |
| | Experimental | 9 | Pre | 17.56±1.09 | 2.23 | 0.06 | 1.5% |
| | | | Post | 17.29±0.93 | | | |

Table 5

Pre and post-test mean scores comparison for static balance, dynamic balance and agility between CG and EG

* Significance level is set at p < 0.05.

Note: SST = Standing Stork Test FSST = Four Step Square Test IAT = Illinois Agility Test.

week for 6 weeks) on dynamic balance and agility of badminton players, they found no significant difference in agility after 6 weeks between EG and CG but significant difference was reported for dynamic balance between EG and CG. The results of this study were contrary to the findings by Bashir et al. (2018) which examined the effects of core training on dynamic balance and agility among junior hockey players whereby it was found that core training had improved dynamic balance and agility of the players. In study of soccer players, Afyon et al. (2017) reported that the 8-week soccer training with core training had improved players' speed and agility.

Effects of Swiss Ball Training on Balance

The post-test results of this study revealed that there were no significant differences between EG and CG for static balance and dynamic balance. However, the performance of the EG was better than CG in static balance (76.4% vs. 18.2%) and dynamic balance (19.4% vs. 15.4%). Similar result was reported by Callaghan et al. (2010) where static spinal stability exercise protocol using Swiss balls had improved back endurance in sedentary people. SBT and conventional physiotherapeutic interventions including traditional techniques such as stretching, strengthening, PNF incorporate the improvement of central, neural and peripheral functioning and thus improves balance (Muniyar & Darade, 2018). Trunk control requires an appropriate sensiori motor ability in order to provide a stable foundation for balance control. It has been shown that the trunk stabilization exercises on unstable surfaces shows improvement

in balance (Lehman et al., 2005; Stevens et al., 2006). A study by Nayak et al. (2012) revealed that SBT improved the trunk control after stroke. SBT has an effect on trunk muscle activity as it influences the anticipatory postural response which might influence the trunk control.

Filipa et al. (2010) investigated the effectiveness of 8 weeks neuromuscular training programme which pivoted on core stability and lower extremity strength on dynamic balance. The programme had improved dynamic balance.

Swiss-ball exercises were extensively used because they could improve strength, endurance, flexibility, coordination, and balance (Karatas et al., 2004). Yu et al. (2017) in a study to investigate the effects of Medicine-ball and Swiss-ball exercises on static and dynamic balance revealed that 6-week exercise programme was effective in improving static and dynamic balance of young adults (Mean age = 22.2years). Similarly, in examining the effects of an 8-week combination programme of core and balance training on single-leg kicking activity among 24 male soccer players, Erdem and Akyüz (2017) found the combination programme had enhanced balance parameters and soccer skills.

Another study of the effectiveness of Swiss ball on improving static and dynamic balance was conducted by Baljinder (2012). In examining 6-week Swiss ball programme on varsity basketball players, Baljinder identified that 45-minute daily session of Swiss ball exercises for 6-week was adequate to improve static and dynamic balance in the EG as compared to CG. Similarly in badminton, Hassan (2017) reported that an 8-week CST had helped EG players improved dynamic balance in the lower extremities. The above-mentioned results were supported by Lacono et al. (2014). In a study of Core Stability Training Programme (CSTP) effects on static and dynamic balance abilities of 20 young male soccer players, Lacono et al. (2014) found that CSTP significantly improved the static and dynamic balance parameters. In another study to compare the effects of 6-week core exercises programme in terms of core stabilization and balance performance (3 days/week, 40 minutes/ day), using Swiss Ball (SBC) and Theraband (TBC) on 22 women aged 25-46 years old, Aksen-Cengizhan et al. (2018) reported that although insignificant differences were found in the post-test mean scores between SBC and TBC groups there was a significant improvement in balance and core stabilization test scores.

Exercises that use balls such as Swiss ball use various parts of the body so that wide-ranging activities could be performed, exceeding the potential of using fixed floors (Chung et al., 2013). Thus, exercising on balls could improve the dynamic balance, the flexibility and stability of the spine (Marshall & Murphy, 2005). As suggested by Anderson and Behm (2005), balance could be maintained through unconscious reflexes of proprioceptive system which obtained information from the joints and muscles. In addition, Lehman et al. (2005) had indicated that local muscles had a greater proprioceptive function, and if the Swiss-ball could exert considerable stresses on the muscles, that could trigger an improved balance effect after SBT.

In investigating the effects of trunk stabilization exercise on the transvers abdominis (TA) and internal oblique (IO) muscle activity and balance ability of average participants, Cha (2018) reported that the trunk stabilization exercise improved the balance ability and increased the activity of the TA and IO muscle. In soccer players, the trunk stabilization exercise for 4 weeks resulted in a significant increase in the muscle activity of the TA and IO muscles (Kim et al., 2010).

Swiss Ball Training and Agility

The post-test result of this study revealed that there was no significant difference between EG and CG for agility. The performance of the EG was better than CG in agility. In fact CG's agility had a negative improvement (-2.4%) as compared to EG positive 1.5% improvement.

The negative improvement in CG did not echo the findings of a research on the effects of stretching on agility by Amiri-Khorasani et al. (2010). It was found that there was significant improvement in agility performance following dynamic stretching as compared to static stretching in both less and more experienced players. Stretching was performed as warm-up activity before soccer training and this could improve agility.

The improvement in agility for EG in this study could be explained by research carried out by Mills et al. (2005). These researchers studied 30 college female volleyball and basketball players aged 18-23 years who were randomly divided into treatment group (TG), pseudo-treatment group (PTG), or control group (CG). Training for the treatment group focused on voluntarily activating the local stability muscles; transversus abdominus (TrA), lumbar multifidi (LM), and the pelvic floor (PF). Results showed improvement in agility $(8.8 \pm 0.7 \text{ s})$ and leg power $(32.3 \pm 4.5 \text{ cm})$ of TG. The training was similar to SBT. Similarly, the result of EG in this study was supported by Pankajbhai and Shantilal (2015) who assessed the effects of CST on running speed of female cricket players, and revealed that 2-week CST improved running speed and agility of 20 female cricket players.

In another study, Afyon et al. (2017) examined the consequences of 8-week core training on speed and agility of soccer players. The experimental group had core training on 2 days (30 minutes per session) of the 4 days per week soccer training while control group had only the soccer training programme. The research results showed non-significant difference in 30m sprint test (CG: 4,56±0,61; EG: 4,53±0,33 sec respectively), Illinois agility test (CG: 16,65 \pm 1,03; EG: 16,34 \pm 1,15 sec respectively) and T-drill agility test (CG: $9,74 \pm 0,98$; EG: $9,51 \pm 0,17$ sec respectively). However, the agility [Illinois Test: CG 4.6% vs. EG 8.9%; T-Drill Test: CG 7.4% vs. EG 14.7%] and speed performance [30-m run test: CG 1.1% vs. 2.0%] of the players improved positively for both groups. This was supported by

Nesser et al. (2008) who found significant relationship between core stability and sprint, vertical jump, agility in male soccer players.

Cressey et al. (2007) studied the effects of 10-week lower-body exercises performed on unstable surface in collegiate males' soccer players. Nineteen players aged 18-23 years were divided into 2 groups (EG=10, CG=9). EG complemented regular training programme with lower-body exercises on inflatable rubber discs and CG performed the same exercises on stable surfaces. No statistically significant differences were apparent between groups. However, significant improvements were observed in both the EG (-2.9%) and the CG (-4.4%) groups over baseline. The result did not show the superiority of working out on unstable surface.

Rebutting the finding of Cressey et al. (2007), Gortsila et al. (2013) reported that different training surfaces (hard or sand surface) had varied effects on agility and passing skills of prepubescent female volleyball players. They found the group that had training on sand surface significantly improved agility as compared to the other two groups that trained on hard surface.

CONCLUSION

The pre-post mean scores have shown that SBT has resulted greater improvement in static balance, dynamic balance and agility in EG as compared to CG. The results support the fact that SBT could be used to provide improvement in the aforementioned measures in college level soccer players. In conclusion, this study provides practical implications for soccer players, physiotherapists, strength and conditioning specialists who can benefit from SBT. Future research could apply longer training duration and involves soccer players from different levels.

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Developmental Pathways of Malaysian National Sports School Athletes

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ABSTRACT

Substantial research compared between specializing and diversifying in a particular sport but few scrutinised across multiple sports. This study examined the developmental pathways taken by individual sport (IS) and team sport (TS) athletes from two Malaysian national sports schools. Student athletes (N=117) aged 16 and above completed the Participation History Questionnaire. Information pertaining to the participant's main sport and other sports he/she was engaged in was obtained. In comparison with TS athletes, the IS athletes were found to have a significant later start for most of their sport-related milestones (p < 0.05). However, the IS athletes (M=14.3 y, SD=1.7) started competing in international competitions significantly earlier than the TS athletes (M=15.3 y, SD=1.1; p = 0.004, d = -0.72) and only the IS athletes reported competing in the Commonwealth, World and Olympic championships. Interestingly, the IS athletes (M=2.5 sports, SD =

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E-mail addresses: tan.angelinat@gmail.com (Angelina Tan Li San) zulezwan@fsskj.upsi.edu.my (Zulezwan Ab Malik) jeffrey@fsskj.upsi.edu.my (Jeffrey Low Fook Lee) *Corresponding author 1.3) participated in significantly more other team sports compared to TS athletes (M = 1.7 sports, SD = 0.7), t(95) = 4.03, p < 0.001, d = 0.80, 95% CI [0.40, 1.19]. The results suggest that athletes who started specializing later and participated in more diverse sports attained higher performance level.

Keywords: Athletes, diversify, specialise, sports school

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INTRODUCTION

Many athletes desire to be on the Olympic podium but current knowledge still does not indicate exactly how athletes attained such status. Among the factors known to affect the development of elite performance in sports involves the athlete (birthdate, heredities, physiological and psychological traits, temperament), the ecosystem (birthplace, support from significant others, athletic support), and practice (type and amount of practice, early specialisation, early diversification; Rees et al., 2016). Of these factors, practice, heredity and psychological traits have been identified as the principal factors influencing the achievement of elite performance in sports (Baker & Horton, 2004). Heredity is unchangeable, psychological state is abstract, whilst practice is tangible. This makes practicerelated factors such as the type and amount of practice to be highly manipulated and analysed.

The Developmental Model of Sport Participation (DMSP) (Côté, 1999; Côté et al., 2007; Côté & Fraser-Thomas, 2007) described two pathways from the start of sport participation to elite performance in sports by differentiating the type of activity (deliberate play or deliberate practice) and number of sports engaged in (one or several). Deliberate play refers to activities engaged primarily for enjoyment, while deliberate practice are effortful activities with the sole purpose to improve skill (Ericsson et al., 1993). According to the DMSP, both specialising and diversifying pathways may lead to excellence in sports, though the authors advocated early diversification. An early specializing pathway would focus on one sport, with many hours of training, commencing from a young age, as opposed to the early diversifying pathway which involves participating in various sports during the early years, before gradually specializing in a single sport. The diversifying pathway involves three distinct linear stages; sampling at ages 6-12 (engage in various sports for enjoyment), specialising at ages 13-15 (engage in a few sports involving both deliberate play and deliberate practice), and investment at age 16 and above (focus solely on one sport with many hours of deliberate practice; Côté et al., 2007).

Numerous studies have been trying to identify the pathway taken by elite athletes. A review provided support for both pathways; specialising or diversifying early equally helps to develop expert sport performers (Coutinho et al., 2016). However, negative outcomes eventuated from specialization (e.g., Bergeron et al., 2015; DiFiori et al., 2014; Jayanthi et al., 2013; LaPrade et al., 2016). These consensus statements and reviews showed that athletes who specialised early experienced injuries, burnout and early retirement from sports, advocating youth athletes to diversify instead. In another study, Fraser-Thomas, et al. (2008) compared 25 competitive adolescent swimmers who dropped out with 25 counterparts who were still swimming, and found that the former achieved success at an earlier age (junior competition level), accumulated more structured swim-related training and participated in fewer cocurricular activities. The authors suggested that early specialisation may be counterproductive to long term athlete development programmes.

Furthermore, multifarious pathways, beyond just specializing or diversifying, have been established. A study involving 256 elite adult athletes from 27 sports identified a non-linear progression of competition pathways (Gulbin et al., 2013). Most of the respondents started engaging in their main sport around the age of 9.1 and followed a mixed pathway to reach elite level. Some progressed directly from junior competitions to senior competitions (akin to early specialisation), some skipped the junior phase and entered directly at the senior phase (playing other sports of varying levels in between; early diversification), and some experienced a down-up progression (from a higher junior level down to a lower senior level before advancing to higher senior levels; early specialisation with later success). A similar varied pathway was also found in another study encompassing 73 Australian track and field athletes who have competed in Olympic and World championships; there were six different pathways distinguished, some started with junior competitions, some started with senior competitions, among others (Huxley et al., 2017). A majority of these track and field athletes began specialising in their main sport between 15-17 years of age (late specialisation) and continued to represent their country for another 8-10 years before retiring at an average age of 32.

Drake and Breslin (2017) compared higher and lower performing international field hockey players and found the former accumulating significantly more practice and competition hours, and commencing consistent coach-led practice and international competitions earlier (analogous to early specialisation) than the latter. Sieghartsleitner et al. (2018) recently identified a specialised sampling pathway that was beneficial for promising footballers. This pathway suggests that those who specialise and engage in varied footballrelated activities, such as beach soccer, playing with school/club/friends/self, playing for leisure, and not just deliberate practice in that sport, are more likely to become renowned footballers. A multi-sport longitudinal research involving Olympians found that the higher achievers were late specialisers, having a later start in their main sport, participating in more other sports, and having a more sustainable sport career (Güllich & Emrich, 2014). A fifth of the athletes in the study by Gulbin et al. (2013) were Olympians but there was no significant difference compared to the other four-fifths. Olympian or not, there is a wide-ranging pathway to elitism. It also implies that studies have yet to determine what sets the Olympian medallists apart from the others.

Malaysia invests a considerable amount of money into sports development with the hope of winning an Olympic gold medal which is still elusive to date. One of the avenues to develop sporting talent is by emplacing students with athletic potential into the national sports schools. Getting

selected into a national sports school would denote one's athletic prowess over the multitude. The student athletes are then groomed exclusively in their main sport and expected to be the next generation of sporting calibre to represent the nation. At present, there are five national sports schools, with the oldest being more than twenty years old and the newest just over two years old. By now, the first cohort of student athletes from the first national sports school would have reached the pinnacle of their sporting career amid some who may have retired since, with a continuous stream of athletes being produced annually. Yet, there is no research on the development and progress of these student athletes. Little is known as to how the athletes developed their sport skills in order to be selected into the sports school. In addition, most research focused on one sport (e.g., Drake & Breslin, 2017; Ford et al., 2010; Fraser-Thomas et al., 2008; Haugaasen et al., 2014; Huxley et al., 2017; Roca et al., 2012; Sieghartsleitner et al., 2018), few studies conducted multi-sport research (e.g., Gulbin et al., 2013; Güllich & Emrich, 2014), which did not involve youth athletes. It is unknown if Malaysian sports development is in line with current literature findings. As such, this research aimed to identify the developmental pathways undertaken by the individual sport (IS) and team sport (TS) athletes in the Malaysian national sports schools.

METHODS

Participants

Student athletes aged 16-21 from eight

sports were recruited from two national sports schools in Malaysia. In order to evaluate their sporting history before enrolling into the sports school and while being in the sports school, 16 was set as the minimum age requirement for this study. This allows for retrospective assessment of the sampling and specialising stages (Côté et al., 2007). The two schools selected were at least 20 years old to ensure that the system is established and sufficient number of student athletes are enrolled. These two schools also have classes for tertiary level, contributing to participants being up to the age of 21, albeit in small numbers. Most student athletes leave the sports school after age 17. It was therefore unsuitable to consider the investment stage for this cohort. The eight sports were further grouped as team and individual sports. The IS and TS categorisation was chosen as it best differentiates the nature of the sports and type of training, creating mutually exclusive groups. 138 participants volunteered in this study. 21 participants were excluded from data analysis due to lack of responses on many items. The remaining 117 participants (70 males, 47 females) were then grouped according to their sports. Breakdown of the number of athletes and their respective sport are listed in Table 1. Permission to conduct the research was granted by the lead institution. Participants provided informed consent prior to commencement of study.

Instrumentation

The Participation History Questionnaire (PHQ; Ford et al., 2010) was adapted to

| Individual sports | n | Team sports | n | |
|-------------------|----|-------------|----|--|
| Archery | 7 | Hockey | 33 | |
| Athletics | 27 | Netball | 15 | |
| Fencing | 17 | Volleyball | 10 | |
| Squash | 4 | | | |
| Swimming | 4 | | | |
| Total | 59 | Total | 58 | |

Table 1Number of participants based on type of sports

enable responses from multiple sports and within a local sports context. The PHQ was originally developed to elicit response from English academy cricket players. This retrospective questionnaire contained three sections; sport-specific milestones, engagement in activities related to the main sport, and involvement in other sports. The first section obtained the age when the participants started significant milestones in their main sport; playing, training and competing at various levels. The second section described the type of activities (coach-led practice, peer-led play) in the main sport and the amount of time (hours per week and months per year) the participants spent in it. The concluding section encompassed other sports that the participants have engaged in; the age when they started and stopped playing, the amount of time spent in those sports, and their highest level of involvement playing that sport. In addition, the participants were also asked what age they were when they enrolled into the national sports school.

The questionnaire was translated into Malay and validated by language and content experts. A pilot test was conducted at a state sports school. Test-retest was conducted for reliability whilst the athletes' parents and coaches were asked to fill in the same questionnaire to validate the athlete's data. The pilot test data were analysed for intra class correlations (ICC) and percentage agreement (PA) to ensure that the data are strongly related and similar. Reliability and validity measures ranged; reliability ICC, r = 0.667 to 0.933, p < 0.05 and PA 50-80%; validity ICC, r = 0.538 to 1.00, p < 0.05 and PA 50-100%. The PHQ have been used by studies involving youth athletes (aged 16-22) and validated (e.g., Ford et al., 2010; Drake & Breslin, 2017; Roca et al., 2012).

Data Collection and Analysis

The questionnaire was completed under the guidance of the lead researcher, at a time to the participant's convenience (non-training and non-studying hours) at the school. Standardized instructions and explanation to complete the questionnaire were provided. Participants were briefed prior to completing each section. For the second section, participants were asked to recall their main sport activities from the present year, working backwards, until the year they first started their main sport. The same reliability and validity tests were conducted as per the pilot study; retest and validation by the parents and coaches, respectively. The data sets completed by the athlete, parent, and coach were compared statistically. The reliability and validity tests yielded similar outcome as the pilot test and were deemed sufficient; retest ICC, r= 0.727 to 1.00, p < 0.05 and PA 50-100%; validity ICC, r = 0.721 to 0.966, p < 0.05and PA 60-70%.

The athletes were grouped according to their respective sports; team or individual. The data was analysed for two age periods: i) 6-12 years, and ii) 13-15 years, based on the DMSP's sampling and specialising stage (Côté et al., 2007). The investment stage (age 16 and above) was excluded due to incongruent data among the participants as the minimum age set for this study was 16 years. Independent t-tests were conducted on the mean for chronological age and developmental milestones (age when first started playing, training, and competing at various levels). The hours for sport activities in main sport for each year between 6 - 15years of age were calculated by multiplying the hours per week by the weeks per year, for each year. Separate 2 groups (team sport, individual sport) x 2 activities (coach-led practice, peer-led play) analysis of variance (ANOVA) with repeated measures on the last factor were performed for 6-12 years and 13-15 years of age. Independent t-test was conducted on the number of other sports. Effect sizes were determined using Cohen's d formula with pooled variance for group means and partial eta-squared (η_p^2) for ANOVA. Effect sizes were based on Cohen's classification; small, medium, large $(d=0.2, 0.5, 0.8; \eta_p^2 = 0.01, 0.06, 0.14)$. The alpha level required for significance for all tests was set at p < 0.05. All analyses were conducted using SPSS 20.

RESULTS

Age

The IS athletes' age (M = 17.8, SD = 1.7) was similar with the TS athletes' age (M =17.8, SD = 1.3). There was no significant difference between IS (M = 14.9 y, SD = 1.7) and TS athletes (M = 14.3 y, SD = 1.8) for the age when they enrolled into the sports school, t(114) = 1.68, p = 0.09, d = 0.31. The athletes enrolled into the sports school at the average age of 14.6 (SD = 1.8). The biggest majority enrolled at age 13 (40%), followed by age 14 (16%), age 16 (15%), age 18 (10%), and the remainders at age 15 and 17 (less than 10% each).

Main Sport Milestones

The IS athletes attained most sport-specific milestones significantly later than TS athletes. The IS athletes started playing their main sport later, t(115) = 3.82, p < 0.001, d = 0.71, 95% CI [0.64, 2.03], started training later, t(115) = 4.08, p < 0.001, d = 0.76, 95% CI [0.70, 2.03], started competing later, t(115) = 3.56, p = 0.001, d = 0.66, started non-sport specific training later, t(115) = 2.53, p = 0.01, d = 0.47, started representing their school later, t(105) = 2.56, p = 0.012, d = 0.49, and started representing their state later, t(114) = 3.38, p = 0.001, d = 0.63. However, the IS athletes started representing the country earlier than the TS athletes, t(74)

= -2.96, p = 0.004, d = -0.72. No significant differences were found between IS and TS athletes for the age when they started representing their district and competing at Asian level. No analysis was conducted for Commonwealth, World and Olympic championships as only the IS athletes had participated in those competitions. The details for main sports milestones are displayed in Table 2.

Main sport activity hours

There was main effect between group and activity for the specialising stage, $F(1, 115) = 4.47, p = 0.04, \eta_p^2 = 0.04$. The TS athletes accumulated significantly more hours than the IS athletes for both coach-led practice

and peer-led play between ages 13-15, as shown in Figure 1. All the athletes displayed significantly higher total amount of time spent for coach-led practice than peer-led play for both sampling, F(1, 115) = 37.45, p < 0.001, $\eta_p^2 = 0.25$, and specialising stages, F(1, 115) = 585.93, p < 0.001, $\eta_p^2 = 0.84$.

Involvement in Other Sports

No significant difference was found for the total other sports engaged in by both IS and TS athletes. The other sports were further analysed under the following categories: other sport-individual sport (OS-IS), other sport-team sport (OS-TS), other sport-sampling stage, other sportspecialising stage, other sport-competitive,

Table 2

Age of athletes for main sport milestones (sample size, mean, standard deviation)

| Milestones | IS athletes | | | TS athletes | | |
|------------------------------------|-------------|------|-----|-------------|------|-----|
| (athlete's age) | n | М | SD | n | М | SD |
| Start sport*** | 59 | 11.5 | 2.3 | 58 | 10.2 | 1.4 |
| Start training*** | 59 | 11.6 | 2.2 | 58 | 10.2 | 1.3 |
| Start competing** | 59 | 11.7 | 2.2 | 58 | 10.5 | 1.1 |
| Start non-sport specific training* | 59 | 13.2 | 1.7 | 58 | 12.4 | 1.4 |
| Start representing school* | 50 | 11.3 | 1.9 | 57 | 10.5 | 1.1 |
| Start representing district | 52 | 11.8 | 1.8 | 58 | 11.2 | 1.1 |
| Start representing state** | 58 | 13.0 | 1.8 | 58 | 12.1 | 1.1 |
| Start representing country** | 45 | 14.3 | 1.7 | 31 | 15.3 | 1.1 |
| Start Asian competition | 23 | 15.0 | 2.2 | 9 | 15.9 | 0.6 |
| Start Commonwealth competition | 3 | 16.3 | 1.2 | - | - | - |
| Start World championship | 11 | 15.7 | 1.8 | - | - | - |
| Start Olympic competition | 2 | 16.5 | 0.7 | - | - | - |

Significant difference between IS and TS athletes: * p < 0.05, ** p < 0.01, *** p < 0.001

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Figure 1. Total hours accumulated for coach-led practice and peer-led play among individual sport (IS) and team sport (TS) athletes in (a) sampling and (b) specializing stages. *Significant difference between IS and TS athletes for specializing stage, p < 0.05. ^Significant difference between coach-led practice and peer-led play, p < 0.001.

other sport-recreational and highest level represented. The IS athletes (M = 2.5, SD =1.3) participated in significantly more OS-TS compared to TS athletes (M = 1.7, SD =0.7), t(95) = 4.03, p < 0.001, d = 0.80, 95% CI [0.40, 1.19]. Supplementary analysis was conducted for the IS athletes to determine if the OS-TS was similar with the main sport. Only athletics and fencing athletes were subject to this supplementary analysis as they had more than 10 participants each who engaged in OS-TS (athletics – 22 participants, fencing – 17 participants), to ensure sufficient sample size for meaningful statistical interpretation. Breakdown into single sports was necessary to compare the actual main sport and OS-TS. Among the athletics and fencing athletes, each OS-TS that had five or more participants were identified. For athletics athletes, the OS-TS were football, handball, hockey, rugby, softball and volleyball. For fencing athletes, the OS-TS sports were handball, hockey, netball and volleyball. In addition, descriptive statistics indicate that the IS athletes participated in more OS-TS, whereas TS athletes participated in more OS-IS; as shown in Table 3.

| Table 5 | Ta | bl | e | 3 |
|---------|----|----|---|---|
|---------|----|----|---|---|

Sample size, mean and standard deviation for the other sports engaged by IS and TS athletes

| | IS athletes | 5 | | TS athlete | s | |
|---------------------|-------------|-----|-----|------------|-----|-----|
| Type of other sport | n | М | SD | n | М | SD |
| Individual sport | 50 | 2.0 | 1.3 | 55 | 2.5 | 1.4 |
| Team sport | 44 | 2.5 | 1.2 | 53 | 1.7 | 0.6 |

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No significant difference was found for the remaining categories of other sports. Almost all the athletes (104 participants) engaged in other sports competitively, seven athletes participated in other sports only for leisure, and two athletes did not engage in any other sport. The highest level represented by the athletes in other sports were school (29 athletes), district (48 athletes), state (26 athletes), and nation (one athlete). The top five most popular other sports were the same for both IS and TS athletes, albeit in differing ranks; these sports are listed in Table 4. Ranking was based on the highest number of participants in each sport.

DISCUSSION

This study found that IS athletes commenced in their main sport later, but progressed to international competitions earlier, and went on to higher levels of competitions, compared to the TS athletes. In addition, the IS athletes participated in significantly more OS-TS than the TS athletes. These findings seem to imply that the IS athletes adopt the early diversification pathway.

Table 4

TS athletes No. IS athletes 1 Cross country Athletics 2 Handball Football 3 Football Cross country 4 Athletics Badminton 5 Badminton Handball

Most popular other sports according to IS and TS athletes

Note. Numbers indicate the popularity rank of the sport for each group.

(39%) competed at the Asian level but only 16% of the TS athletes have similar experience, with no TS athletes competing in the Commonwealth, World and Olympic championships. This infers that the IS athletes have higher achievements at this point of time, for being able to qualify to enter major world competitions, but it is unknown if the current performance will reflect future successes; junior success does not necessarily produce adult world champions (Güllich & Emrich, 2014; Huxley et al., 2017).

More than a third of the IS athletes

The athletes reported significantly more hours for coach-led practice, compared to peer-led play, during both the sampling and specialising stage. The early diversification pathway infers that the sampling stage would consist of more deliberate play, whilst the specialising stage would consist of both deliberate play and deliberate practice (Côté et al., 2007). The higher amount of practice hours since young reflects the early specialisation pathway; specialisation require more hours of deliberate practice (Ericsson et al., 1993; Güllich & Emrich, 2014). Conventionally, play was the main activity in the early years, though people are overtly unaware of the benefits derived from playing. Due to urbanisation such as shrinking of public playing spaces, heightened concerns over safety, and the increase of sport-specific developmental hubs at schools and community centres, children tend to engage in more structured activities. This may explain the high amount of practice hours during the sampling stage.

No difference shown in total other sports participation between groups was similar to previous studies (e.g., Drake & Breslin, 2017; Haugaasen et al., 2014). However, further analysis by categorising the other sports suggests that most of the national sports school athletes participated in more other sports that are in different domains than their main sport. For fencing, the only similarity between the main sport and OS-TS would be that they are all non-cgs sports [i.e. sports that are not measured in centimeters (c), grams (g), or seconds (s)]. For athletics, all the OS-TS may have provided avenues to develop basic multi-lateral movements that contributed to higher mastery of specialised athletics events. It is possible that a variety of sports contribute to an athlete's mastery in their main sport, as shown by the early diversification pathway (Anderson & Mayo, 2015; Güllich & Emrich, 2014; Huxley et al., 2017).

More than half the athletes (56%) enrolled into the national sports schools between ages 13-14. This is slightly earlier than what is propositioned by the DMSP's investment stage (age 16 and above). It is possible that sports school enrolment is linked to academic milestones, rather than sport specialisation, as sports schools are under the Ministry of Education. The majority of the athletes enrol at the age of 13 likely as it coincides with the start of the secondary school year. Presumably, those who miss the first principal intake (at age 13) overflow to the following year (at age 14). Similarly, the third and fourth largest enrolment also coincide with student related milestones, whereby age 16 is when students get categorised based on their preferred academic streams (science or art stream), and age 18 is the start age for tertiary education. Age 15 and 17 are the ages when major school examinations take place, hence, few would embark on a major change to their school.

In Malaysia, organised sports commence in school, with annual competitions between schools, districts and states based on age groups (under 12, under 15, and under 18) for a variety of sports. The national level competitions are a common hunting ground for coaches seeking potential athletes. Selected athletes are offered a place in the sports school. The athletes may choose to take the offer or remain where they are. With this sports system, there is a linear, chronological pathway provided for student athletes. However, neither the IS nor TS athletes conform completely to the proposed DMSP pathways, as shown in Table 5. This agrees with other studies that an athlete's career does not adhere to a single pathway alone (Coutinho et al., 2016; Gulbin et al., 2013; Güllich & Emrich, 2014). The athletes
in this study started their main sport before the age of 12, with more hours of deliberate practice, but they also participated in more other sports that were different from their main sport since young.

Developmental pathway refers to the route taken in the process of embarking on an athletic career. Although the analysis was only up to age 15, the term developmental pathways was embraced as this study includes where the athletes were before enrolling (sampling stage) and while being in the sports school (specialising stage). Furthermore, the inclusion of the investment stage will not alter the pathway features stated in Table 5, apart from their current competition level, which may change at any time, not just within the investment stage.

CONCLUSION

The main aim of this study was to identify the developmental pathway of IS and TS athletes in the Malaysian national sports school. A combination of both sampling in other sports and specialising in main sport from a young age was found among elite junior athletes, some of which have competed in senior international competitions. Those who excel better at the current age start their main sport later. This study is limited by the athlete's age whereby the minimum age of 16 provides an overview of the sampling and specialising stages of the DMSP, but not the investment stage. Follow-up study on the athlete's current sport activities will be conducted.

Further research on adults who have previously enrolled in a national sports school is indispensable to determine long term effects of specialised sports participation. Similarly, a comparison between athletes who have been through the sports school system versus those who did not is needed to establish the effectiveness of the sports school programme. In addition, it is possible that student athletes may benefit from a later enrolment into sports school, as advocated by multiple consensus statements for youth sports, but this requires additional research.

Table 5

Main characteristics of the pathways taken by the IS and TS athletes

| Features | IS athletes | TS athletes |
|-----------------------------------|---|-------------------------------------|
| Start main sport | Later | Earlier |
| Start representing country | Earlier | Later |
| Deliberate practice | Start young | Start young |
| Current highest competition level | Above Asian level | Asian level and below |
| Other sport involvement | More team sports | More individual sports ^a |
| | 1 | |

^aBased on the mean and standard deviations, without statistical significance.

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Combined Strength Training on Throwing Ball Velocity in Softball

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ABSTRACT

One of the most important skills in softball is throwing. Various methods of training were tested to determine an alternative approach that can improve throwing ball velocity. Combined training is one method that recently gained attention among sports practitioners. However, most training focuses only on the major muscles and neglects supporting muscles such as handgrip and trunk rotation muscles that are also critical in the execution of throwing. Therefore, this study seeks to determine the effect of handgrip, trunk rotation, and combination of handgrip and trunk rotation training on the throwing ball velocity of collegiate female softball players. A total of 72 collegiate female softball players were assigned into 4 strength training groups namely handgrip (HG), trunk rotation

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ISSN: 0128-7702 e-ISSN: 2231-8534 (TR), combination (HG&TR) group (CB) and control group (CG). All participants had undergone a training program, 3 days per week for 6 weeks. All groups were instructed to perform the same basic strength training program (training on major muscles) with different additional strength training (handgrip strength or trunk rotation strength) according to the group's assigned exercises. Participants were assessed on their throwing ball velocity before the intervention (pretest) and after the 6-week training program (posttest). After 6 weeks of training, the result showed that throwing ball velocity significantly increased in the HG (1.45 m/s), TR (1.62 m/s), CB (2.08 m/s) and CG (0.93 m/s) groups. The post-hoc test indicated that all groups were significantly different compared to each other except the comparison between HG and TR groups. This study also demonstrated that the combination training (CB) approach was more effective in improving throwing ball velocity compared to a single mode approach (HG and TR).

Keywords: Handgrip, throwing ball velocity, trunk rotation, softball

INTRODUCTION

Throwing is one of the most vital skills in softball. This skill requires more attention during training to enhance performance since all softball players are required to use this skill regardless of their position on the field. Primarily, one of the variables that can improve throwing performance is throwing ball velocity (Escamilla et al., 2012). To gain an advantage over the opponent, throwing ball velocity is crucial to prevent the opposing runner from achieving more runs (Potter & Johnson, 2007).

Throwing velocity has been studied in various sports and in various training programs in order to look for an alternative exercise to improve throwing performance (Szymanski, 2012). However, Szymanski (2012) also emphasised that it was not clear as to which type of training could best improve throwing ball velocity.

Strength training is one of the approaches that is commonly used to develop the performance of throwing ball velocity (Escamilla et al., 2010; Szymanski, 2012). This training develops selective muscle groups that are specifically engaged during throwing (Zawrotny, 2005). Development of certain muscle groups that are particularly involved in throwing will enhance the execution process of the overhead throw by maximising the efficiency of the kinetic chain (McDaniel et al., 2009; Moynes et al., 1986). The full throwing execution begins with the process of energy transfer from the lower body towards the trunk, shoulder, elbow, wrist, and fingers (McDaniel et al., 2009; Moynes et al., 1986). Each body part has their own function during throwing which defined the throwing performance itself. Szymanski (2012) reviewed 39 journal articles about training on overhand throw and found inadequate studies that emphasised the significance of handgrip strength, body rotation strength, or the combination of both handgrip and body rotation training.

Handgrip Strength and Throwing Ball Velocity

In general, throwing involves movement of the upper body which affects the whole arm segment including handgrip motion (Koley & Kumaar, 2012). According to Shea (2007), players' grip strength is an essential aspect in sports that require upper body movement and those that require holding an object such as basketball, baseball, handball, softball and so on. In addition, McDaniel et al. (2009) supported the argument where an improvement in handgrip strength not only improved the skill of gripping the object but also improved force production in throwing. Basically, grip strength can increase the ability of the hand to grip the ball and generate control over the ball during throwing (Ferragut et al., 2010). The amount of force generated in the handgrip, indirectly enhances the spin of the ball that leads to the improvement in throwing velocity (Takahashi et al., 2001).

The power of handgrip motion is the result of a forceful flexion of the whole finger joint with maximum voluntary force (Goswami et al., 2016; Shea, 2007). Shea (2007) emphasised that gripping involved most of the muscles in the forearm and hand which totaled to 35 muscles. The composition of the gripping action comprised flexion and extension. The study claimed that the flexor mechanism of the fingers was 62% higher than the extensor mechanism. Hence, a proper training program which emphasises on flexion and extension movement is crucial in handgrip strength development.

Trunk Rotation Strength and Throwing Ball Velocity

Apart from handgrip strength, trunk rotation strength is also involved in the energy transfer process and force production during throwing and this may help to maximise throwing ball velocity. According to Robb et al. (2010), in developing necessary torque and velocity for an overhead activity such as throwing, the important element is the hip motion and trunk rotation. A successful throwing technique with the presence of throwing velocity is derived from the effectiveness of the energy transfer process from the lower body, facilitated by the trunk, and forward to the upper body (Aragon, 2010). Study of the overhand throw showed that 46.9% of throwing ball velocity was generated during the stride and trunk rotation, and 53.1% by the arm action (Zawrotny, 2005). In other words, the lower extremities which includes hip and trunk rotation produced almost as much energy as the arm itself in during throwing.

The role of trunk rotation strength in throwing velocity was supported by Stodden et al. (2008). They noted that the increase of pelvis and trunk rotation velocity intensified throwing ball velocity which maximised performance. The increase of pelvis and trunk rotation velocity created higher force production to the throwing arm which leaded to an improvement in throwing velocity. Stodden et al. (2008) also noted that improvement in trunk rotation strength was important to increase dynamic stabilisation during throwing which was useful during the follow-through phase. Therefore, the risk of injury such as muscle imbalance could be reduced if the muscular strength of trunk rotation is properly developed by the athletes.

Generally, training exercises should focus on every muscle that is involved in the execution of a specific movement or skill. However, most training programs are designed to only focused on the main muscles that generate energy in a throwing

process such as arm and legs (McDaniel et al., 2009; Park et al., 2014; Pedegana et al., 1982; Zawrotny, 2006). The significance of the supporting muscles that also contribute in a throwing process tends to be ignored. Handgrip and trunk rotation strength are the supporting muscles that assist in the accomplishment of a throwing process and these muscles have been neglected in training. In addition, the combined effect of both strength training (handgrip and trunk rotation) has not been investigated and discussed since there are inadequate studies that focus them together. In response to the current problem, the purpose of this study is to identify the effect of handgrip, trunk rotation, and combination of both strength training in improving the throwing velocity of collegiate female softball players.

METHODOLOGY

Subject

A total of 72 healthy female softball players participated in this study. The participants were from University Technology Mara, Malaysia and were all right-handed collegiate female softball players. The participants were assigned into 4 groups with each group having 18 participants. Prior to the study, all participants were screened and only those who were free from current or prior injuries and illnesses were included from the study. Written consent was obtained from all the participants prior to the beginning of the study.

Instrumentation

The ball velocity during throwing was measured using a radar gun (Bushnell Speedster Speed Gun; Bushnell Inc, Lenexa, KS) with an accuracy of 1.61 kph (1 mph) (Bowman et al., 2006). The intraclass correlation coefficient (ICC) reported a 0.95 during the pre-study reliability test indicating it had high reliability.

Procedure

Throwing Velocity Assessment. Based on the procedure guidelines by Tilaar and Marques (2013), the position of the radar gun (Bushnell Speedster Speed Gun) was placed around 1 meter behind the target. A target was provided to control the projectile of the travelling ball and was placed parallel to the ball direction. The participants were given a maximum of 5 throwing trials and recording was made for each trial. The distance between the participant's position and the throwing target was 10 meters. Following a pre-investigation trial session, it was identified that the ball projectile is minimum within this distance. Hence a 10-meter distance had been set in this study to measure the throwing ball velocity. This had been supported by Escamilla et al. (2010) which indicated that the critical peak velocity in throwing occurred within the middle distance between bases. In addition, to prevent muscular fatigue during the throwing test, 30 seconds of rest was given to all participants between throwing trials. The throwing ball velocity was measured twice, before (pretest) and after (posttest) the 6-week training intervention program.

Training Description

All experimental training groups participated in 3 sessions of resistance training for 6 weeks. The training sessions were conducted in an indoor environment (gymnasium) and performed on 3 separate days in a week with at least 1 day of rest between sessions. Each session (50 min) began with a warm-up of slow stretching and movement exercises (10 min) and ended with cool-down exercises (10 min). After the warm-up, the participants start the basic strength training for all groups. The basic strength training program comprised 2 categories which were core exercises and assistance exercises. Table 1 below shows the training program for the 6-week intervention.

In addition to basic strength training (core and assistance exercises), each experimental group was given a specific training program which was different according to the specifics of each group. For the handgrip group (HG), besides the basic resistance-training program, an additional 6 specific handgrip exercises were assigned to this group. For the trunk rotation group (TR), an additional 6 specific trunk rotation exercises were assigned. As for the combined training group (CB), an additional 6 combination specific exercises (3 specific handgrip exercises and 3 specific trunk rotation exercises) were assigned. Lastly, the control group (CG) only performed the basic strength training without any additional specific exercises given. Table 2 shows the list of exercises for each group.

The exercises in the basic strength training program utilised the intensities based on the core and assisted exercise training program (Table 1). All the exercises in the specific training program consisted of assistance exercises as indicated in Table 2.

| | XX7 1 1 | XV 1 0 | W 1.2 | XX 7 1 4 | W 1.5 | W 1 (|
|------------|---------------------|--------|--------|-----------------|--------|--------|
| | weeк 1 | week 2 | week 3 | week 4 | week 5 | week 6 |
| | Warm-up | | | | | |
| Sets | 2 | 2 | 2 | 2 | 2 | 2 |
| Repetition | 10 | 10 | 10 | 10 | 10 | 10 |
| % 1RM | 40 | 40 | 45 | 45 | 50 | 50 |
| | Core exerci | se | | | | |
| Sets | 2 | 3 | 3 | 3 | 3 | 3 |
| Repetition | 4-6 | 4-6 | 2-4 | 4-6 | 1-2 | 2-4 |
| % 1RM | 80 | 80 | 85 | 85 | 90 | 90 |
| | Assistance exercise | | | | | |
| Sets | 2 | 3 | 3 | 3 | 3 | 3 |
| Repetition | 8-10 | 8-10 | 6-8 | 8-10 | 6-8 | 8-10 |
| % 1RM | 65 | 65 | 70 | 70 | 75 | 75 |

Table 1

Training program

% 1RM = Percentage of Estimated One Repetition Maximum

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Table 2

List of exercises

| Category/ groups | | Handgrip strength training group | Trunk rotation strength training group | Combination strength training group | Control group |
|---------------------|----------------------------|-------------------------------------|--|---|----------------------|
| | | Chest press | Chest press | Chest press | Chest press |
| | | Squat | Squat | Squat | Squat |
| | Core exercises | Stiff-leg deadlift | Stiff-leg deadlift | Stiff-leg deadlift | Stiff-leg deadlift |
| Basic | | Abdominal crunch | Abdominal crunch | Abdominal crunch | Abdominal crunch |
| training | | Biceps curl | Biceps curl | Biceps curl | Biceps curl |
| 0 | | Seated row | Seated row | Seated row | Seated row |
| | | Dumbbell press | Dumbbell press | Dumbbell press | Dumbbell press |
| | | Triceps extension | Triceps extension | Triceps extension | Triceps extension |
| | | Barbell reverse wrist curl | Kneeling cable lift | Barbell reverse wrist curl | |
| | Assistance exercises | Barbell wrist curl | Kneeling cable chop | Barbell wrist curl | |
| | Hammer cable wrist curl | Woodchop cable | Hammer cable wrist curl | | |
| training | | Hammer cable reverse wrist curl | Seated cable core rotation | Kneeling cable lift | |
| | | Cable wrist curl | Standing cable core rotation | Kneeling cable chop | |
| | | Cable reverse wrist curl | Torso rotation | Torso rotation | |

The exercise order in this study followed the sequence of exercises by alternating the agonist and antagonist, and the upper and lower body exercises when it seemed appropriate in each session. The training exercise was based on Zawrotny (2005) and the training guidelines were adopted from Baechle and Earle (2008).

Data Analysis

Data from the study was analysed using

the Statistical Package of Social Sciences (SPSS) program software version 20.0. A one-way ANOVA on pretest data and mean gained score was conducted. Firstly, the pretest data was analysed for homogeneity between groups. Then, the mean gained was calculated (posttest-pretest) to determine the treatment effect prior to the main analysis. Finally, the significant difference on throwing ball velocity between the 4 groups was identified.

RESULT

Table 3

The results of the pretest indicated that there was no significant difference for throwing ball velocity between the 4 groups (HG, TR, CB and CG): F (3, 68) = 0.018, p = 0.997. This shows that all groups were homogeneous prior to the experiment. Table 3 below presents the mean and mean gained score of the pretest and posttest result of all groups.

Based on Table 3, the CB group showed the highest change with a mean difference of 2.08 m/s, followed by the TR group with 1.62 m/s and the HG group with 1.45 m/s. Concurrently, the CG group displayed the least improvement with a mean difference of 0.93 m/s.

The results of the one-way ANOVA on the mean difference (mean gained) showed that there were differences in the throwing ball velocity among the 4 groups: F (3, 68) = 26.174, p = 0.000. Subsequently, the Tukey HSD test analysis to compare the 4 groups (HG, TR, CB and CG) showed that there were significant differences between all groups (p < 0.05) except between HG and TR (p=0.557). Among all the groups, CB had the highest mean difference compared to CG with a mean gained of 1.15 m/s.-

DISCUSSION

The results of this study showed significant differences among all the groups except for the comparison between HG and TR groups. However, among all the groups, the CB group displayed the greatest improvement in throwing ball velocity. The findings showed that the combination of specific training approach has a synergy effect towards the improvement of throwing ball velocity compared to the single specific training approach. Handgrip and trunk rotation strength are important factors in the development of throwing velocity since both of these strengths play an important role during throwing where the movement contributes in producing greater force which increase its maximum velocity.

Similarly, trunk rotation strength also generates the same effect as handgrip strength. Trunk rotation does not only act as a medium to forward energy from the

| DDE TEST DOST TEST |) |
|---|---|
| Group N Mean (SD) Mean (SD) Mean (SD) m/s m/s | , |
| HG 18 17.70 (2.41) 19.15 (2.40) 1.45 (0.38) | |
| TR1817.74 (2.10)19.37 (1.81)1.62 (0.47) | |
| CB1817.66 (2.08)19.74 (2.02)2.08 (0.37) | |
| CG 18 17.82 (2.08) 18.75 (2.06) 0.93 (0.35) | |

| Mean score and mean | 1 gained score fo | r throwing ball | velocity |
|---------------------|-------------------|-----------------|----------|
|---------------------|-------------------|-----------------|----------|

HG = Handgrip strength training group, TR = Trunk rotation strength training group, CB = Combination strength training group and CG = Control group

lower to the upper body, but it also can be used in force production to increase throwing velocity. Trunk rotation strength could increase force to the throwing arm and indirectly improve throwing ball velocity (Stodden et al., 2008). Fleisig et al. (2013) biomechanically explained how trunk axial rotation could increase throwing velocity. Trunk rotation begins during the windup phase. The athlete starts to rotate the pelvis to face the target while ensuring that the upper trunk is parallel to the direction of throwing. Immediately after the foot touches the ground, maximal trunk rotation occurs, and trunk axial acceleration is at its peak at this point. The throwing arm is externally rotated as the pelvis and upper trunk rotates, and the acceleration of the movement increases in accordance with the force production created by the muscle contraction (Fleisig et al., 2013). This is where trunk rotation strength can produce a greater force to improve throwing ball velocity. Moreover, Sakurai (2000) stated that the ball could only be accelerated to 50% of that attained in the normal throwing motion without trunk rotation.

Among the 4 groups, the CB group had shown the greatest improvement with a change of 2.08 m/s. Furthermore, the CB group also showed a significant improvement compared to the other groups where the mean difference between CB and HG is 0.63m/s, CB and TR is 0.46 m/s, and CB with CG is 1.15 m/s. This study revealed that combination training (CB) was far more effective to a single mode approach (HG and TR) in improving throwing ball velocity. As mentioned earlier, handgrip strength is effective to increase the backspin of the ball during throwing (Kinoshita et al., 2017; Takahashi et al., 2001) while trunk rotation strength can maximise trunk rotation acceleration on the overhead throw movement (Fleisig et al., 2013; Prieske et al., 2016). Therefore, it is not surprising that the combination training approach involving handgrip and trunk rotation exercises has created the synergy effect on the throwing performance.

The CB group had benefited from both strength training exercises whereby this training intervention group comprised both movements (handgrip and trunk rotation) which involves the usage of different muscles. The number of muscle unit development also plays an important role that leads to this significant finding. The CB group had the advantage of using different type of muscles and this technically led to an increase in multiple muscular strengths. A significant improvement in maximum muscular strength can significantly increase force production in the throwing process (Hong et al., 2001; Moynes et al., 1986). The development of muscles also contributed to the successful synergy process which is crucial in the energy transfer process. It can be concluded that the improvement that occurs in the CB group is technically due to the advantage of both strength training.

CONCLUSIONS

A complete throwing process involved various muscular strengths. However, this study demonstrated that the throwing

velocity was affected by the handgrip and trunk rotation strength which influenced softball performance. This study also emphasised that the combination of handgrip and trunk rotation strength (CB) was more effective compared to the training program that only used a single specific training approach (HG, TR, and CG). Therefore, athletes should include a combination of various training approaches that utilise different muscle groups in their training program to maximise throwing ball velocity and improve their softball throwing performance. Since there are other throwing sports such as javelin throw, handball, cricket, tennis, water polo, and baseball which also utilise handgrip and trunk rotation strength, more studies are needed to determine their specific roles.

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The Comparison between Major Muscle Activations during Different Phases in Softball Batting

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ABSTRACT

Muscle activation in baseball swing is a subject which has been extensively studied compared to softball swing. However, muscle activation in baseball swing should not be generalised to softball swing due to differences between these sports in terms of ball size, speed, and the angle of pitch. This study aims to identify major muscle activations during different phases in softball batting, namely loading, contact, and follow through. Ten female softball players participated in twenty trials of hitting a stationary ball. The peak normalized sEMG for all muscles during softball batting phases was analysed and recorded as the percentage of maximum voluntary contraction (% of MVC). During stance, it was found that left pectoralis major involved the highest muscle activity with 9.08% of MVC, while the right rectus abdominus involved the least muscle activity with 1.43% of MVC. During the loading phase, the right middle deltoid involved the least muscle activity with 7.03% of MVC. During the contact phase, the highest muscle activity was observed from the right external oblique with 23.93% of MVC, while the least muscle activity with 7.98%

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rajanuruljannat@gmail.com (Raja Nurul Jannat Raja Hussain) keekm@tarc.edu.my (Kee Kang Mea) rizal@um.edu.my (Rizal Razman) shariman_ismadi@salam.uitm.edu.my (Shariman Ismadi Ismail) maisarahshari87@gmail.com (Maisarah Shari) of MVC was observed from the right biceps femoris. During the follow through phase, left gastrocnemius involved the highest muscle activity with 18.09% of MVC, while right posterior deltoid had the least muscle activity with 4.49% of MVC. Overall, although nearly the same muscles were involved in softball and baseball swing, different activation patterns were shown by several muscle groups during softball

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swing. These findings would be useful for coaches to develop training programmes which specifically aim for the improvement in softball batting performance.

Keywords: Activation, batting, muscles, phases

INTRODUCTION

Softball batting involves highly skilled movements as the batter must decide where and when should the contact with the ball occur. It is crucial to master the skills of batting in order to master various styles of pitching, namely fastballs, breaking balls, and changeups. Several factors are taken into account in proper batting, such as bat speed and accuracy in predicting the contact point (Ae & Koike, 2011; Fortenbaugh, 2011).

A batter generates batting speed through a kinetic link, where sequential recruitment patterns of muscles occur, transferring the momentum from large musculature to smaller adjacent muscles (Milanovich & Nesbit, 2014). Prior to the impact between the bat and ball, the first movement is to shift the body weight to the back foot. This is followed by stepping, landing, and shifting the body weight to the front foot. Furthermore, multiple measurements, such as bat velocity kinematics, the kinetics of movements (Southard & Groomer, 2003), and ground reaction force (GRF) (Katsumata, 2007) were previously examined in lab to identify the mechanisms involved in softball and baseball batting performance. In addition, surface electromyography (sEMG) has been used to analyse batting. To date, only one comprehensive study

investigated batting performance using sEMG. To be specific, Shaffer et al. (1993) found that a skilled baseball swing relied on a synchronised transfer of muscle activity, which started from the lower limbs to the trunk and finally to the upper limbs.

Although muscle activation in baseball was measured in this study, it could not be assumed that the same muscles were involved in softball swing as well. To illustrate this point, one of the differences between baseball and softball sport is the method of ball throwing by the pitcher, which may cause various reactions from the batter. Furthermore, both baseball and softball sports involve different forms of pitching release which influence the trajectory of the ball. Generally, baseball pitcher throws the ball over his head, and the mount that the pitcher stands on is 10.5 inches high. As a result, the ball which is thrown moves on a downward flight to the batter. Therefore, the baseball batter has to create a slight uppercut swing movement in order to get the bat on the plane of the pitch. Whereas, in softball, the mount where the pitcher stands on is not elevated. Moreover, the pitcher releases the pitch below the hip. Consequently, a ball can be released at the thigh level and end up at the sternum level, which is technically located at the top of the strike zone in softball. With the backspin force being placed on the pitched ball, the ball would move on an upward flight towards the batter. For this reason, the softball batter must create a slight downward swing in order to match the plane of the risen ball. Due to this circumstance, it was hypothesised in this study that the muscles activities performed during softball swing would vary from the ones performed in the baseball swing.

In addition, it was found in previous studies that some variations in muscle activity occurred even in similar movements in other sports. For example, contradictory findings were present in McHardy and Pollard (2005) and Lim et al. (2002)'s studies regarding muscle activities during a golf swing. Essentially, there are five phases in the golf swing, namely backswing/take away, forward swing, acceleration, early follow through, and late follow through. McHardy and Pollard (2005) found that abdominal obliques and pectoralis major were highly activated during the acceleration phase. However, Lim et al. (2002) found that only abdominal obliques were highly activated during the acceleration phase. With these being highlighted, it is important to identify the specific muscles being activated in various sports, especially those which share similar movements. These findings would contribute insights for coaches to be more specific in the training they provide for the improvement in athlete's batting performance.

This study attempts to identify the major muscle activities involved in softball swing. The knowledge regarding muscle recruitment would be useful for the improvement in the batting performance among junior players and beginners. Therefore, more empirical data are needed to gain an enhanced understanding of the muscle groups which are involved in softball swing execution.

METHODS

Surface Electromyography activities in batting were measured and evaluated. Following that, the sequence of swing movement was monitored with a high-speed video camera.

Participants

The participants consisted of 10 right-handed college female players with age of 24.90 ± 0.74 years old, the height of 156.00 ± 1.05 cm, and weight of 52.30 ± 1.83 kg. All participants were injury-free during data collection. Moreover, they had obtained collegiate-level experience in playing softball and they also represented their university at university level tournaments.

The tests were performed on two separate days. On the first day, the participants were evaluated for their ball hitting, which was done with a full swing for 20 times. They were then provided with 2 days of rest before the manual muscle test (MMT) was conducted. The participants were instructed to eat and drink normally before and during the test day. In addition, besides being instructed to avoid any strenuous exercise for 24 hours before the test, they were also instructed to sleep normally the night before the test. All of them received detailed explanations of the test procedures and risks of the research before the start. Accordingly, written informed consent was obtained from all participants. The procedures for this study had also been approved by the Ethic Committee of the Research Management Institute (RMI), Universiti Teknologi MARA, Malaysia (600-RMI [5/1/6]).

Procedure

For sEMG data recording, a wireless Myon 320 sEMG system by Myon AG was used. Due to a limited number of studies conducted on softball swing, the major muscle groups involved in the previous studies regarding baseball swing were selected for this study, as shown in Figure 1 (Vansuch, 2013). Surface electromyography electrodes were bilaterally attached to the selected muscles.

Based on Figure 1, the major muscle groups involved were pectoralis major (PM), triceps brachii (TB), biceps brachii (BB), anterior deltoid (AD), middle deltoid (MD), posterior deltoid (PD), rectus femoris (RF), biceps femoris (BF), gastrocnemius (G), latissimus dorsi (LD), external oblique (EO), rectus abdominus (RA), and tibialis anterior (TA). The protocol of electrode placement was performed according to Criswell (2010) protocol.

The areas where the electrodes would be attached to the participants' skins were firstly shaved and cleaned with an alcohol swab (McHardy & Pollard, 2005). Kendall Medi-TraceTM 530 electrode type (Ag/AgCl differential electrode) was used together with AQUA-TAC. Two electrodes were attached to a single Myon transmitter. As



Figure 1. Muscles evaluated in softball swing

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a result, 32 electrodes were attached to the selected muscle groups in the participants' bodies per session. Every transmitter was also secured on the body using medical grade tape.

Prior to the recordings for warm-up and familiarisation with the test conditions, a practice session with 15 loose swings and 5 full swings was conducted. To prevent any effects of fatigue during the trials, the batter was given 10 seconds of break before the next trial. All participants used the same bat, which was 2014 BUSTOS (-10); Demarini, Hilsboro OR, USA, with a length of 0.864 metres and weight of 680 gram.

The sampling rate of the sEMG signal recording was set at 2000Hz using 20-450 Hz bandpass filter. Power frequency spectrums of the raw data were firstly identified using FFT analysis pipeline in proEMG 2.0 to observe the characteristics of the artefact noises. Furthermore, Butterworth Low-Pass (450 Hz) and High-Pass (20 Hz) filters were used before a notch filter was set at 200Hz with a steepness of 0.99. Root mean square (RMS) values of the filtered raw data were calculated in subsequent analysis. Following that, the procedures of sEMG signal recording were similar to the ones in the previous study, where wireless Myon 320 sEMG system was used to measure muscle activities (Rashid et al., 2015).

All the muscle electrical signal values of activities were recorded in percentages of the maximum neural drive. Meanwhile, a participant performed an isometric maximal voluntary contraction (MVC) of the selected muscles. Therefore, MVC data was obtained by enquiring the participants to perform maximum isometric contractions during the test.

After all the muscles were tested in sEMG recording, the MVC test was conducted on them. Before the test, each participant performed two to three submaximal contractions for all muscles tested as warm-ups. Familiarisation to the test procedure was also performed. During each MVC test, when the participants were instructed to perform these submaximal contractions with their maximum effort within a 4-second period, they were given a verbal form of motivation. Isometric contractions were performed three times for each muscle, and all muscles were tested independently after a 1-minute rest period. Moreover, manual muscle testing protocols were implemented according to Hislop and Montgomery (2009). An MVC value was determined as the highest mean of sEMG amplitude observed during the MVC task. These recording procedures were based on the sEMG recording conducted in previous studies (Fujii et al., 2009a; Fujii et al., 2009b).

Video recording was made on the batting movement on the sagittal plane (refer to Figure 2) using a high-speed camera with 240 Hz frame rate (Casio EX-ZR 800, Co., Ltd., Tokyo, Japan). The synchronisation of the video images and the sEMG signals were accomplished using an iPhone timer application (HIIT & Tabata). This application simultaneously performed recordings for both camera and electromyography reading. Furthermore, the participants were instructed to perform 20 batting trials for each session in an indoor Raja Nurul Jannat Raja Hussain, Kee Kang Mea, Rizal Razman, Shariman Ismadi Ismail, Maisarah Shari and Norizzati Mohd Idris



Figure 2. Sagittal plane

lab. During the trials, they had to hit a stationary ball on a batting tee. The batting tee height was adjusted to the batter's hip level, while the ball was placed on the top of the batting tee. The ball position should be adjusted to the level of the batter's navel. Essentially, this position is the normal level of a pitched ball which is within the range of batter's strike zone. Meanwhile, the strike zone is the space above the home plate which is placed between the level of the batter's armpit and above the knee (Association, 2013).

To clarify the movements of the selected muscles during batting, the movement sequences were categorised under 4 phases (refer to Figure 3):



Figure 3. Phases in softball swing

The sequences of movements involved were:

- Stance: The phase before the shift in body weight with no specific movement.
- (2) Loading (initiation of the stepping motion of the left foot): The onset time was defined by the batting

movement which was videorecorded when the left foot moved off the ground.

(3) Contact (initiation of the bat swing movement until ball contact): The onset time was based on the videorecorded movement. This was specifically during the moment when the left hand started to move down and forward until contact occurred between the ball and the bat.

(4) Follow through: The phase which began after the impact between the ball and the bat.

RESULTS

Table 1

For each muscle, the maximum sEMG level (EMG_{max}) was obtained from the MVC test.

This level was used to normalise the sEMG data collected during swing trials:

$$NSEMG = \frac{SEMGm}{SEMGmax}$$

NsEMG_m refers to the normalised sEMG data of the muscle m, while sEMG_m represents the filtered sEMG data of the muscles during the swing. The calculation of the muscle activity percentage was performed using Microsoft Excel software.

| | EMCCC | 1.00 | 1 1 | | 1.00 | 1 | C | C1 11 | |
|---------------------------|------------|----------|-----------|-------|-----------|--------|-------------------|----------|-------|
| Values of neak normalized | E MILT TOP | αιπρέρητ | muscies a | urino | αιπρέρρητ | nnases | $\alpha t \alpha$ | sotthall | SWING |
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| Muscles | (1) Stance | (2) Loading | (3) Contact | (4) Follow Through |
|-----------------------------|------------|-------------|-------------|--------------------|
| Right Middle Deltoid | 3.86 | 7.03 | 9.61 | 6.21 |
| Left Middle Deltoid | 4.80 | 11.37 | 15.41 | 12.24 |
| Right Anterior Deltoid | 6.52 | 12.69 | 17.81 | 15.07 |
| Left Anterior Deltoid | 6.44 | 11.41 | 11.62 | 6.27 |
| Right Biceps Brachii | 3.84 | 10.32 | 14.16 | 6.40 |
| Left Biceps Brachii | 3.66 | 13.81 | 20.09 | 13.92 |
| Right Rectus Abdominus | 1.43 | 8.49 | 16.18 | 9.39 |
| Left Rectus Abdominus | 2.20 | 9.38 | 17.16 | 9.19 |
| Right Pectoralis Major | 5.76 | 22.81 | 16.95 | 15.05 |
| Left Pectoralis Major | 9.08 | 15.64 | 19.51 | 10.56 |
| Right External Oblique | 2.58 | 15.20 | 23.93 | 13.97 |
| Left External Oblique | 2.17 | 15.21 | 19.01 | 11.74 |
| Right Rectus Femoris | 2.83 | 18.37 | 23.57 | 16.01 |
| Left Rectus Femoris | 2.16 | 18.03 | 13.36 | 10.66 |
| Right Tibialis Anterior | 1.81 | 12.40 | 16.97 | 14.67 |
| Left Tibialis Anterior | 1.82 | 14.16 | 19.03 | 15.57 |
| Right Posterior Deltoid | 2.90 | 7.38 | 10.94 | 4.49 |
| Left Posterior Deltoid | 3.80 | 13.55 | 10.63 | 9.50 |
| Right Latissimus Dorsi | 3.89 | 11.00 | 13.91 | 7.47 |
| Left Latissimus Dorsi | 2.46 | 13.06 | 17.22 | 7.60 |
| Right Triceps Brachii | 2.72 | 20.07 | 15.71 | 11.02 |
| Left Triceps Brachii | 2.58 | 12.85 | 11.85 | 7.14 |
| Right Biceps Femoris | 2.52 | 20.60 | 7.98 | 13.09 |
| Left Biceps Femoris | 4.31 | 18.18 | 17.55 | 10.83 |
| Right Gastrocnemius | 3.56 | 22.32 | 15.30 | 13.64 |
| Left Gastrocnemius | 5.26 | 20.87 | 19.19 | 18.09 |

Table 1 displays the peak of the normalisation of EMG muscle activation during different phases of a softball swing, which was represented in percentages. During the stance phase, Left Pectoralis Major showed the highest contraction at 9.08%, while Right Rectus Abdominus showed the lowest contraction at 1.43%. In the loading phase, Right Pectoralis Major showed the highest contraction at 22.81%, with Right Medial Deltoid showing the lowest contraction at 7.03%. During the contact phase, Right External Oblique displayed the highest contraction at 23.93%, while Right Biceps Femoris displayed the lowest contraction at 7.98%. Lastly, during the follow-through phase, Left Gastrocnemius displayed a high contraction at 18.09%, while the lowest contraction was shown by Right Posterior Deltoid at 4.49%.

DISCUSSION AND IMPLICATIONS

Baseball and softball swing is one of the most challenging skills in sports as the players need to have the contact happen between the ball and a round bat (Milanovich & Nesbit, 2014). Due to insufficient empirical data on softball swing, an analysis of softball swing movement patterns is required so that the particular muscle activities involved in the swing movement of softball players could be identified.

The selected major muscles involved in baseball and softball swing were investigated in softball batting among female softball players. Identifying the types of muscle activation during the batting motion is important to gain an understanding of the functions of these muscles throughout the batting sequence. Additionally, it was recently found that various muscle activations occurred during different phases. Overall, pectoralis major and external oblique have essential roles in assisting right-handed batters in their swings.

It was commonly hypothesised (Welch et al., 1995) that the muscles involved during softball swing would be similar to the ones involved in the baseball swing. However, this study found several differences between baseball and softball swing in terms of muscle activity patterns. The previous study by Kitzman (1964) found that the muscle activity shown by left pectoralis major ranged from moderate to very strong during the loading, contact, and follow through phases in the baseball swing. Conversely, it was found that the right pectoralis major was highly activated only during the loading phase. Meanwhile, there was a high activation of left pectoralis major during the stance phase in softball swing. Therefore, this finding suggested that there were several variations between baseball and softball in terms of the swing movements. The difference between the left and right pectoralis major activities might be due to the varied preparations done the swings done in softball and baseball. Moreover, the increase in left pectoralis major muscle activity recorded in baseball could be attributed to the distance taken by pectoralis major when the bat was brought back during the loading phase. Moreover, Kitzman (1964) mentioned that higher left pectoralis major muscle activity was recorded as the participants brought the bat farther back during the loading phase. Therefore, in softball swing, it was shown that the participants took a shorter distance when the bat was brought back. This action was comparative to the ones done in a baseball swing, specifically during the loading phase and stance phase. This was possibly due to the softball players' belief that shorter distances will provide fast batting speed compared to longer distances (Flyger et al., 2006).

This study found that external oblique showed the highest muscle activity during the contact phase in softball swing. Vansuch (2013) stated in his book that external obliques were also involved during the contact phase in the baseball swing. Furthermore, Shaffer et al. (1993) showed in their study that abdominal muscle, erector spinae, and abdominal obliques showed high muscle activity during pre-swing, swing, and follow through phases, with an MVC percentage from 60% to 100%. Higher muscle activity in the torso was possibly due to the torso rotational movement which occurred during the swing phase in softball and baseball (Chu et al., 2015). With these being highlighted, the importance of these muscles groups could be seen.

During the follow through phase, it was found that the left gastrocnemius displayed the highest muscle activity at 18.09%. On the other hand, in baseball swing, gastrocnemius muscle was listed as one of the activated muscles only during the loading phase (Vansuch, 2013). The high activation of the gastrocnemius muscle was possibly due to the softball players' main focus on maintaining their balance after contact. Lafont (2007) highlighted in his study that balance was one of the most important contributing factors to a successful softball hit and the achievement of gaze control in hitting. Furthermore, balance is essential to stop body rotation which may occur during contact with the ball. In addition, Rahman et al. (2017) found that gastrocnemius muscle had the highest activity pattern when the lower body balance was maintained. This indicated that gastrocnemius muscle played an important role in balancing. Therefore, it was also justified that the activity pattern of the gastrocnemius muscle was the highest in this study as the body balance was balanced and body rotation was stopped after contact with the ball.

It could be seen from Table 1 that there was an involvement of other muscle activities during each phase in softball swing. Although the pectoralis major showed the highest muscle activity during the contact phase, there was also a high activation of biceps femoris and rectus femoris. Additionally, both of these muscles were constantly active until the follow through phase.

Both softball and baseball battings involve a complex whole-body movement to generate power which is needed to hit a ball with spatial and temporal accuracy. This movement is based on a coordinated sequence of muscle activities to produce a fluid and reproducible swing (Welch et al., 1995). Furthermore, batters use the kinetic chain to transfer energy from the lower limb to the trunk, upper limb, bat, and the ball. When a bat, racquet, or stick is used in sports, the hitter attempts to transfer maximum energy to the ball in order to produce an impact. A previous study regarding the serves in tennis suggested that a number of body segments must be coordinated in a sequence to produce optimal racquet position, trajectory, and velocity upon impact with the ball (Fortenbaugh, 2011).

Moreover, a batter is also able to generate bat speed by utilising a kinetic link. Through this link, the sequential recruitment pattern of muscles occurs, transferring momentum from large musculature to smaller adjacent muscles (Welch et al., 1995). Stronger muscles will initiate the movement and transfer the momentum to the next activated muscles, creating an impact on the swing. Therefore, it is crucial for coaches to identify the specific muscles involved in a swing movement. Besides, specific muscles should be trained and increased in strength to produce a greater impact on the ball contact between the bat and ball.

CONCLUSION

In this study, the muscle activity of the upper and lower extremities among female players during softball batting was investigated using sEMG and a high-speed video camera. It could be concluded from the findings that several major muscle groups, such as pectoralis major, rectus femoris, biceps femoris, external oblique, triceps brachii, biceps brachii, and latissimus dorsi are essential for the execution of softball swing. It was also indicated in this study that muscle activity patterns vary between softball swing and baseball swing. Last but not least, these findings may provide notable insights to coaches and strength conditioning professionals in creating effective training programmes. These training programmes are essential for the improvement in the strength of muscles which are mainly engaged in softball swing.

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Coaching Strategies to Manage Youth Athlete Behaviour in Football

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ABSTRACT

One of the most important objectives of sport coaching is the creation of a positive learning environment in which athletes can develop the technical skills required for success as individuals and as a team. Problems relating to athlete misbehaviour during practice sessions can impact upon the quality of the learning environment. The purpose of this study was to observe sport coaches to determine the effectiveness of strategies used to manage athlete behaviour. Twenty-eight youth football coaches were observed in a coaching setting to identify the behaviour management strategies used to manage their athlete's behaviour. The findings demonstrated that coaches incorporated a limited number of behaviour management strategies. Results from observations indicated that coaches used consequent strategies to control athlete behaviour with an over-reliance on verbal, as opposed to nonverbal strategies. Furthermore, the data demonstrated that coaches utilized more intrinsic rather than extrinsic behaviour management strategies to manage athlete behaviour to allow athletes opportunities to optimize their sporting potential.

Keywords: Athlete, behaviour management strategies, positive coaching environment, sport coaching

INTRODUCTION

Historically children have always engaged in physical activity during play time, however the past century has seen a major increase in organised sporting programs for youth

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ISSN: 0128-7702 e-ISSN 2231-8534 (Visek et al., 2015). When guided by caring sensitive and informed coaches, children can experience positive developmental gains and cultivate a healthy attitude to physical activity (Bailey et al., 2013). Recent research (Partington & Cushion, 2013; Partington et al., 2014) has focused on the use of systematic observation strategies to identify the coach's emphasis on training form and playing form within a coaching session. While the outcomes of this research

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have provided an understanding of the types of activities coaches implement to improve athlete performance, they have failed to recognise periods of inactivity during a training session, interventions used by a coach to manage transitions between activities and general athlete behaviour. Accordingly, there is still much to be revealed about the behaviour management procedures that underpin effective coaching - how to provide a supportive environment for athletes, how behaviour management procedures are carried out in practice, and ways of evaluating the effectiveness of behaviour management strategies.

A significant number of young athletes are entering sporting teams and recreational environments unable to cope with the demands of the learning environment and display inappropriate behaviours (Kerr et al., 2016). Thus, Kerr and Stirling (2015) and Lavay et al. (2015) emphasised that sports coaching required a strong behaviour management underpinning to ensure supportive environments were created for athletes. In order to manage athlete behaviour effectively coaches are required to use different strategies during each phase (warm-up, body, cool-down) of the coaching session, and both antecedent and consequent strategies should be employed.

Research conducted to date has endeavoured to identify and highlight specific behaviours or models of coaching behaviour (Chelladurai, 1993; Hall et al., 2016; Low et al., 2013; Smith & Smoll, 1984). As coaching involves many facets, research in the field needs to move beyond simple surface level analysis of instructional behaviours and coaching techniques to the development of coaching strategies to manage athlete behaviour during periods of inactivity and when transitioning between activities. Discipline is a key responsibility of coaches as behaviour problems are considered one of the major obstacles to successful coaching (Kerr et al., 2016). The coaching environment, in which the space is open and the athletes are not constrained, creates more unique difficulties in managing inappropriate behaviour than in the classroom setting (Keegan et al., 2010). Coaches who implement inappropriate behaviour management strategies are at risk of negative consequences including inappropriate athlete behaviours which may result in athletes not reaching their full potential (O'Connor et al., 2018). Therefore, creating a positive environment with effective behaviour management strategies is a key responsibility of the coach.

The purpose of this study was to observe sport coaches in a coaching setting to identify the effectiveness of the strategies used when managing athlete behaviour. The findings would assist coaches in the selection of effective strategies to improve their communication and control in the coaching environment.

METHOD

Participants

Twenty-eight football coaches were observed in a coaching setting. The participant selection process involved the researcher contacting the sporting organisations seeking permission to access the coaches. Forty coaches were initially approached and provided with a participant information and consent form. From the forty coaches initially contacted, twenty-eight responded they were willing to be involved in the research. The coaches who volunteered to be observed were responsible for the training and development of football players ranging from 8 - 12 years. All coaching candidates observed were male and ranged from 25 - 46 years.

Procedure

Two researchers observed the coaching sessions while interacting with the coach at certain stages to seek clarification of specific instances. The researchers did not interact with the athletes or participate in the training activities. The two observers sat independently of each other and positioned themselves in an unobtrusive location on the field whilst observing the coaches and taking anecdotal notes of the behaviour management instances. Each time a specific behaviour management instance was observed, it was recorded on a coding sheet. The training sessions varied in length from 45 minutes to one hour and were conducted during the competitive football season. Athletes attended two training sessions and competed in one competitive football game per week against teams from other clubs.

All participants involved in the research study followed a similar format when conducting training sessions, which included three distinct phases: a warm-up; body; and a cool-down. Following the observations, checks for inter-observer agreement were conducted to ensure the accuracy of the data. The anecdotal notes of each researcher were collated and tabulated.

Data Analysis

In the current study, data analysis and interpretation were an integrated and continual process. When analysing the data, three main strategies were employed: 1) collation of the data; 2) identification of open codes throughout the data; and 3) interpretation of the data. Coding techniques were used in the data analysis which allowed for the identification of categories throughout the data. Coding was used as a method of data collection and analysis involving a review and meaningful examination of the anecdotal notes (Miles & Huberman, 1994). Primarily, the objective was to create basic categories which required the researcher to minimise the difference between comparative groups (Glaser, 1998). In this study, coding of data commenced immediately following collection. The objective of open coding was to produce emergent categories and their properties which were applicable for amalgamating into theory.

RESULTS

This section considers the commonalities that exist between the coaching behaviour management instances during each of the three phases of a coaching session - warmup, body of session, and cool-down. For this purpose, this section is organised under the following headings: behaviour management commonalities in the warm-up, body of the session, and in the cool-down. At any stage during the observations if the coach used a behaviour management strategy this is referred to as an 'instance'.

Behaviour Management Commonalities in the Warm-Up

There were 112 observed behaviour management instances in the warm-up phase of the coaching sessions, of which only 25% (n=28) antecedent strategies were included, compared to 75% (n=84) consequent strategies. Table 1 provides an overview of the instances observed during the warm-up phase and highlights the strategies implemented by the coaches to address behaviour management instances.

During this phase, as highlighted in Table 1, there was an even distribution of both positive and negative outcomes. Forty-seven percent (n=52) of the instances were followed with a positive outcome (resulted in the athlete following instructions and exhibiting the desired behaviour) and 53%

(n=60) with a negative outcome (resulted in the athlete ignoring the coach's instructions and exhibiting inappropriate behaviour). Most of the strategies were implemented via the use of verbal communication with only 28% (n=32) non-verbal strategies observed, with 50% (n=16) of these a mixture of verbal and non-verbal. Furthermore, of the 112 observed instances, only 25% (n= 28) were antecedent strategies. Another commonality identified from the data analysis of the warm-up phase was the coaches' use of strategies with an intrinsic dimension. Of the 112 instances observed in the warm-up phase of the coaching sessions, 64% (n=72) were strategies that included an intrinsic dimension, whilst 36% (n=40) demonstrated an extrinsic dimension.

The data analysis conducted on the warm-up phase of the coaching session has highlighted the importance of antecedent strategies with an extrinsic dimension as a method of establishing expected behaviours throughout the coaching sessions. This analysis has also identified the extent to which these coaches rely on verbal communication strategies.

| Instances | 112 Behaviour Management Instances Observed |
|-----------------------|---|
| Antecedent/Consequent | 28 antecedent |
| | 84 consequent |
| Positive/Negative | 52 positive outcomes |
| | 60 negative outcomes |
| Verbal/Non Verbal | 80 verbal strategies |
| | 32 non verbal |
| | 16 verbal and non-verbal |
| Extrinsic/Intrinsic | 40 extrinsic |
| | 72 intrinsic |

Table 1Observed instances during the warm-up

Behaviour Management Commonalities in the Body

Most of observed behaviour management instances were observed in the body of the coaching sessions. As outlined in Table 2, a total of 172 behaviour management instances were observed during this coaching phase. Of the 172 observed behaviour management instances, there was an even distribution of outcomes, with 48% (n=84) positive outcomes and 52% (n=88) negative outcomes. The majority of the strategies used by the coaches during this phase were verbal in nature. Like the observational instances during the warm-up phase, the percentage of instances during which the coaches used strategies with an intrinsic as opposed to extrinsic dimension was notable, with only 34% (n=60) of the instances demonstrating an extrinsic dimension. In summary, the number of behaviour management instances which were observed during the body of the coaching sessions were much greater than observed in the warm-up phase of the coaching session. This marked increase is assumed to be due to the instructional nature that encompasses the body of a coaching session. Despite a significant emphasis on consequent verbal strategies, an even mix of positive and negative outcomes was observed.

Behaviour Management Commonalities in the Cool-Down

The most frequent commonality evident during the cool-down phase of the coaching session was the lack of observed behaviour management instances. In comparison to 112 and 172 instances that occurred respectively during the warm-up and body of the coaching sessions, only 44 behaviour management instances were observed during the cool-down phase. Most of the observed training sessions contained minimal instruction, with the coaches incorporating a fun concluding game for the athletes. The quantity of instances that occurred during the cool-down was only 15% of the total number of instances in all three of the coaching phases. The observed instances during this phase are outlined in Table 3.

| Instances | 172 Behaviour Management Instances Observed |
|-----------------------|---|
| Antecedent/Consequent | 20 antecedent |
| | 152 consequent |
| Positive/Negative | 84 positive outcomes |
| | 88 negative outcomes |
| Verbal/Non Verbal | 128 verbal strategies |
| | 4 non-verbal |
| | 40 verbal and non-verbal |
| Extrinsic/Intrinsic | 60 extrinsic |
| | 112 intrinsic |

Table 2Observed instances during the body

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| Instances | 44 Behaviour Management Instances Observed |
|-----------------------|--|
| Antecedent/Consequent | 8 antecedent |
| | 36 consequent |
| Positive/Negative | 16 positive outcomes |
| | 28 negative outcomes |
| Verbal/Non Verbal | 28 verbal strategies |
| | 12 non-verbal |
| | 4 verbal and non-verbal |
| Extrinsic/Intrinsic | 12 extrinsic |
| | 32 intrinsic |

Table 3Observed Instances during the cool-down

Of the total observed instances only 18% (n=8) of the 44 were antecedent strategies as opposed to 82% (n=36) consequent strategies. A high proportion of negative outcomes were observed in the cool-down phase, with only 36% (n=16) positive outcomes as opposed to the other phases of the coaching session, which had a relatively even distribution of positive and negative outcomes. The final commonality between the coaches during the cool-down phase was the explicit number of observational instances which involved verbal strategies with an intrinsic dimension. It should be highlighted that this high occurrence of verbal strategies with an intrinsic dimension was a common occurrence across all phases of the observed training sessions.

DISCUSSION AND CONCUSION

The findings from this research identified that coaches incorporated limited behaviour management strategies in their coaching practice. Specific behaviour strategies that were observed do however have strong correlations to effective strategies for classroom behaviour management. These include removing and discussing the problem behaviour privately with the athlete (Rogers, 1995) and removing or isolating the athlete from the activity (Rogers, 1995). The results from the observations indicate that coaches use minimal antecedent strategies (setting up rules and expectations prior to an activity), as many of the strategies were consequent strategies used in response to athlete inappropriate behaviour. Specific antecedent strategies identified during the observations include the establishment of rules and boundaries, however this was not common practice. On the other hand, consequent strategies were put in place once the inappropriate behaviour had occurred, an example being discussing the problem with the athlete and removing the athlete from the group. From a total of 328 observed behaviour instances during the field observations, only 17% (n=56) were deemed as being antecedent strategies, as opposed to 83% (n=272) consequent strategies. Links have been made between research conducted by behavioural theorists

regarding the inclusion of antecedent strategies (Canter,1990) and the practice of the coaches in this study. The links imply that the absence of antecedent strategies (e.g., Canter's establishment of expectations) have resulted in a high occurrence of observed instances deemed to have a negative outcome (inappropriate behaviour displayed by the athlete). For this purpose, sport coaches need to place more emphasis on the establishment of rules and expectations to reduce inappropriate behaviour displayed by their athletes.

Further findings highlight the coaches' over-reliance on verbal behaviour management strategies. According to many behavioural theorists (Canter, 1990; Jones, 2000; Rogers, 1995; Skinner, 2002), the implementation of non-verbal communication is an effective means of managing behaviour (e.g. using a whistle to get the attention of the athlete). Nonverbal communication is identified as an effective method of halting inappropriate and avoiding verbal reprimand. However, the findings of this research indicate that coaches placed a substantial emphasis on verbal strategies as a technique for managing inappropriate behaviour. From a total of 328 observed behaviour instances during all phases of the coaching sessions, 72% (n=236) were verbal strategies.

The data suggest that coaches incorporate more behaviour management strategies into their practice that are intrinsic in nature as opposed to extrinsic. Intrinsic motivation was employed by all coaches through all phases of the coaching sessions during the field observations. From the data of the observed behaviour instances, 66% (n=216) were deemed to be intrinsic. Despite this, extrinsic motivation is commonly used for conditioning human behaviour and is an effective strategy for managing athlete behaviour. Rewards and verbal reinforcers can be used initially to establish behaviour expectations (e.g. praising the athlete for doing the right thing or having an award at each training session for 'best on field'). This strategy of using extrinsic motivators is identified as particularly effective for coaches when building rapport with athletes. Coaches do however need to be aware of the overuse of extrinsic conditioning which, should be perceived as one of a range of strategies for managing athlete behaviour.

Behavioural theorists (Canter, 1990; Jones, 2000; Rogers, 1995; Skinner, 2002) indicate a range of strategies are required for effective behaviour management. Specific examples of effective strategies may include: verbal (e.g. verbal praise - "well done for putting the balls away"); non-verbal (e.g. clapping a student when they have done the right thing); intrinsic (e.g. emphasis on athlete enjoyment during training); extrinsic (e.g. trophies or reward system); antecedent (e.g. establishing rules prior to an activity); and, consequent (e.g. giving an athlete a warning that they will miss out on the activity if they keep acting inappropriately). Results from this research highlight that coaching practices included a limited range of behaviour management strategies, with 90% of the strategies verbal, 75% of the strategies intrinsic, and 80% of the strategies consequent. To ensure coaches provide a positive environment for their athletes in which effective behaviour management is conducted, coaches should incorporate a wide range of strategies, rather than relying on consequent and verbal approaches. Coaches should select methods that require the least intervention but are still effective in achieving the desired behaviours. Managing behaviour is a practical, hands-on activity, similar to coaching (Sports Coach UK, 2009). Therefore, coaches need to determine the techniques that are most beneficial for themselves and their athletes. This winwin scenario allows athletes to develop to their full potential and coaches to receive a rewarding and satisfying experience -asituation that both groups will wish to repeat in future training sessions.

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Effects of Acute Aerobic Exercise, Dehydration and Ad Libitum Fluid Consumption on Mood and Choice Reaction Time in Trained Females: A Distributional Analysis

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ABSTRACT

This study investigated the effect of acute aerobic exercise, dehydration and fluid intake on choice reaction time (CRT) and the ex-Gaussian CRT distribution. On 4 separate occasions, 8 trained females (body mass [BM]: 61.8 ± 10.7 kg; VO_{2 max}: 46.3 ± 7.5 mL·kg⁻¹·min⁻¹) lost 2.0±0.3% BM cycling at ~75% VO_{2max} (~60 min, $24.2\pm0.9^{\circ}$ C) before commencing a 1 h recovery period with *ad libitum* access to one of 4 beverages: Water, Powerade[®] Isotonic (SD), Up&Go EnergizeTM (HP-MILK) and Up&Go Reduced SugarTM (LS-MILK). Participants had an additional 15 min to consume food (e.g. muesli bars, fruit, bread and condiments) *ad libitum* at the end of the 1 h period. CRT and mood (concentration and alertness) were assessed 'Pre-Exercise', ~5 min 'Post-Exercise' and 'Post-Recovery'. Median CRT decreased Post-Exercise (401±48 ms) compared to Pre-Exercise (420±48 ms, *p*=0.025) and Post-Recovery values (427±49 ms, *p*=0.050). This improvement was localized to the μ -component of the ex-Gaussian CRT distribution (Pre-Exercise: 393±40 ms; Post-Exercise: 366±47 ms; Post-Recovery: 395±52 ms, *p*=0.018); the spread and skew of the distribution (i.e. σ - and τ -parameters) was unchanged across trials (*p*'s>0.05). The effect on μ was relatively consistent across each exercise occasion (Hedges' *g* range: 0.32–0.63).

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danielle.mccartney@griffithuni.edu.au (Danielle McCartney) b.desbrow@griffith.edu.au (Ben Desbrow) gcox@bond.edu.au (Gregory R. Cox) c.irwin@griffith.edu.au (Christopher Irwin) * Corresponding author No changes in mood were identified across time (p's>0.05). While beverage intake was similar across treatments (p=0.351), differences in total (i.e. food plus fluid) energy (p=0.014) and carbohydrate (CHO) (p<0.001) consumption were observed. Still, the type of beverage consumed did not affect mood, CRT or the ex-Gaussian CRT distribution (p's>0.05). Acute aerobic exercise provides a cognitive performance

ISSN: 0128-7702 e-ISSN 2231-8534 benefit, which appears to outweigh any adverse effects imposed by dehydration in the immediate post-exercise period in trained females.

Keywords: Cognitive function; cognitive performance; fluid intake; reaction time distribution

INTRODUCTION

Improvements in cognitive performance have been observed following acute aerobic exercise (Chang et al., 2012; Lambourne & Tomporowski, 2010; Tomporowski, 2003). These improvements, which have been observed across multiple cognitive domains, are transient, generally lasting ~15 min (Chang et al., 2012; Lambourne & Tomporowski, 2010), and are thought to occur, in part, as a result of elevated cortical concentrations of catecholamines, leading to increased physiological arousal (Chmura et al., 1998; Chmura et al., 1994). While exercise alone may enhance cognition, it is important to recognise that prolonged physical activity is often accompanied by large sweat losses (i.e. 'dehydration') (Thomas et al., 2016). When fluid losses exceed ~2.0% body mass (BM), impairments in cognitive function may occur (Masento et al., 2014). Therefore, dehydration could potentially oppose any cognitive-enhancing effects that result from physical exercise (Chang et al., 2015).

Several studies have investigated the effect of acute aerobic exercise on cognitive performance in dehydrated individuals and these have yielded inconsistent results (Grego et al., 2005; Irwin et al., 2018; Serwah & Marino, 2006; Turner et al., 2017; Wittbrodt et al., 2015; Wong et al., 2014). This inconsistency may be partly due to temporal variation in cognitive ability. Indeed, studies suggest that performance on cognitive tasks typically fluctuates from one occasion to the next. Thus, a single cognitive assessment may only capture one of many possible performance outcomes for a particular individual (Nesselroade & Salthouse, 2004; Rabbitt et al., 2001; Salinsky et al., 2001; Salthouse & Berish, 2005; Salthouse et al., 2006). To date, only one study has repeated cognitive assessments under standardized conditions to verify the magnitude and direction of exercise-induced cognitive effects in dehydrated individuals (Irwin et al., 2018). Irwin et al., (2018) observed a significant improvement in choice reaction time (CRT) in well-trained males ~15 min post-exercise, despite large fluid losses (-2.5% BM loss). The effect was replicated on 4 repeated trials that standardized exercise intensity and duration. To our knowledge, no study has measured the reproducibility of exercise-induced cognitive effects in dehydrated females. This is important, as females appear to exhibit attenuated plasma catecholamine responses to exercise compared to males (Zouhal et al., 2008), which may affect exercise-mediated cognitive performance changes (Chmura et al., 1998; Chmura et al., 1994).

The aforementioned inconsistencies (Grego et al., 2005; Irwin et al., 2018; Serwah & Marino, 2006; Turner et al., 2017; Wittbrodt et al., 2015; Wong et al., 2014) may also be due to differences in the analytical approach applied when examining

performance data. For instance, reaction time, a common measure of cognitive function, is often analysed using estimates of central tendency, i.e. the mean or median response speed to a set of reaction stimuli. This can be problematic, as the "shape" of a CRT distribution can change without affecting central tendency, leading to falsenegative reports (Heathcote et al., 1991). An alternative analytical approach involves fitting a distribution function to the data and using the parameters of the curve to identify regional changes in CRT performance (Ratcliff, 1979). The ex-Gaussian function, for instance, returns estimates for three parameters: (1) the mean (μ) and (2) standard deviation (SD) (σ) of the Gaussian (normal) component (i.e. the fastest reaction speeds), and (3) the mean and SD of the exponential component (τ) (i.e. the degree of positive skew) (Whelan, 2008), thereby facilitating a more comprehensive analysis of performance changes that may occur.

This study aimed to investigate the effect of acute dehydrating aerobic exercise on mood, CRT and the ex-Gaussian CRT distribution in trained females. Four standardized trials were conducted to test the reproducibility of the results. A secondary aim of this study was to determine the effect of consuming different beverages and food voluntarily (i.e. *ad libitum*) post-exercise on cognitive performance. We hypothesized that acute exercise would initially improve CRT, despite significant levels of fluid loss, and that the benefit would dissipate following a period of recovery involving consumption of food and fluid.

METHODS

The methodology of this study is provided in detail in a companion paper exploring the rehydration potential of different beverages consumed *ad libitum* with food (McCartney et al., 2019a). This manuscript will briefly summarize the methods related to the cognitive performance component of the study.

Participant Characteristics

Female cyclists/triathletes (training ≥ 3 h cycling·week⁻¹) aged 18–45 y were eligible to participate. A sample size calculation (G*Power Version 3.1.9, Kiel University, Germany, 2014) using a power $(1-\beta)$ of 0.80, α =0.01 and effect of 0.55 (*R*=0.60) (Irwin et al., 2018) indicated that ~ 8 participants would be needed to detect a significant effect of acute exercise on CRT. To account for possible attrition, 10 volunteers were recruited. One participant withdrew due to training schedule conflicts; a second withdrew due to poor availability. Eight participants (age: 33.2±7.4 y; BM: 61.8±10.7 kg; VO_{2max}: 46.3±7.5 mL·kg⁻ ¹·min⁻¹; peak power output (sustainable) (PPO): 244±32 W; Mean±SD) completed all four experimental trials. The Griffith University Human Ethics Committee (GU 2017/730) approved the investigation and all procedures were undertaken in accordance with the agreement of Helsinki.

Experimental Design

Each participant attended the laboratory on 6 occasions. Initially, a medical screen and a graded cycling test to determine

VO_{2max} and PPO (see companion paper: McCartney et al. 2019a) were conducted. Participants then completed a full trial as a familiarization prior to four experimental trials (at least 5 d apart). Trial order was counterbalanced and scheduled during the follicular phase of the menstrual cycle (participants using hormonal contraceptives [n=3] were tested while taking the active drug). Each trial involved dehydration via exercise followed by a recovery period (1 h duration) during which ad libitum access to one of 4 beverages was permitted: (1) Water, (2) Powerade® Isotonic (Coca Cola Ltd.) (SD), (3) Up&Go Reduced SugarTM (Sanitarium[®], Australia) (Lower Sugar [LS]-MILK), and (4) Up&Go Energize[™] (Sanitarium®, Australia) (Higher Protein [HP]-MILK). Participants had an additional 15 min to consume food ad libitum at the end of the 1 h period. A CRT test and subjective feelings questionnaire (SFQ) were administered 'Pre-Exercise', ~5 min 'Post-Exercise' and 'Post-Recovery'.

Pre-Trial Procedures

Prior to trials, participants were instructed to: (1) avoid alcohol (>24 h); (2) abstain from caffeine-containing products and avoid moderate-strenuous exercise (>12 h); (3) provide a record of the food/fluid they consumed (24 h); (4) consume a pre-prepared evening meal (~60 kJ·kg⁻¹) (Campagnolo et al., 2017); and, (5) avoid food/fluid overnight (~10 h). Following the first trial, a duplicate of the food record was provided to the participant to encourage replication of dietary intake in the 24 h preceding each trial.

Experimental Procedures

On arrival to the laboratory (~ 7 AM), participants compliance to the pre-trial procedures was confirmed. Subsequently a sample of urine was collected and the urine specific gravity (U_{SG}; Palette Digital Refractometer, ATAGO, USA) was determined. At familiarization, one participant recorded a pre-exercise U_{SG} \geq 1.024, suggesting a degree of dehydration (Armstrong et al., 2010). In response, 600 mL of water was provided to the participant who had their urine reassessed 30 min following the fluid ingestion, resulting in a $U_{SG} < 1.024$. This beverage administration was undertaken on all subsequent trials for consistency. The remaining participants all provided initial urine samples assessed as U_{SG} <1.024 at each visit. Euhydrated participants then completed the Pre-Exercise CRT test, SFQ, and recorded a nude BM measurement.

Dehydration occurred via heat exposure (10 min; $\sim 70^{\circ}$ C) in a portable sauna, followed by cycling (24.2±0.9°C; 66±11% relative humidity [RH]) on an electronicallybraked ergometer (Lode Excalibur Sport; Lode BV, Groningen, Netherlands). Exercise commenced at 60% PPO; individuals were permitted to adjust the intensity at 20 and 40 min ($\pm 5-10\%$ PPO) (the minimum permitted workload = 50% PPO). Heart rate (HR) (Ambit3, Suunto[®], Vantaa, Finland) was recorded every 10 min throughout exercise; respiratory gasses were also measured to allow for determination of exercise intensity and energy depended during exercise (see companion paper: McCartney, et al. 2019a).

Nude BM was measured following 60 min of exercise and when BM loss was <1.8% from baseline BM, participants continued cycling until the target BM loss was achieved. The exercise program (duration and intensity) established at the familiarization trial was replicated on the subsequent trials. Dehydrated participants completed the Post-Exercise CRT test and SFQ ~5 min after ceasing exercise. Individuals showered prior to a final nude BM measurement (i.e. ~30 min Post-Exercise). Fluid loss was estimated as the difference between the Post-Exercise BM and the Pre-Exercise BM.

Participants consumed one of 4 beverages ad libitum over a 1 h recovery period: (1) Water; (2) SD (Energy: 103 kJ·dL⁻¹; carbohydrate [CHO]: 5.8 g·dL⁻¹); (3) HP-MILK (Energy: 344 kJ·dL⁻¹; CHO: 9.9 g·dL⁻¹; Protein: 6.7 g·dL⁻¹; Fat: 1.5 g·dL⁻ ¹); or (4) LS-MILK (Energy: 279 kJ·dL⁻¹; CHO: 8.9 g·dL⁻¹; Protein: 3.4 g·dL⁻¹; Fat: 1.5 $g \cdot dL^{-1}$). At 1 h, a variety of food items (e.g. fruit, muesli bars, bread and condiments, see McCartney, et al., 2019a) was made available which could be consumed ad libitum for 15 min. They then completed the Post-Recovery CRT test and SFQ. All food and fluid was weighed to the nearest 1 g to determine total beverage, energy and CHO intakes (FoodWorks ® Version 8, Xyris Software Pty Ltd, Brisbane, Australia).

Cognitive Function Test and Subjective Feelings Questionnaire

A ~2 min (40 stimuli per set) computerized 4-choice CRT test (Inquisit 4 Lab; Millisecond software, LLC, Seattle,

Washington) was administered (Irwin et al., 2018). Four black boxes programed to turn red at random intervals (400-2000 ms) were displayed on a white background. Participants pressed the keyboard key corresponding to the red box as quickly as possible (each key was located directly below the corresponding stimuli). Median CRT and the percentage of correct responses to stimuli (CRT accuracy) were assessed in response to each set of stimuli. The SFQ consisted of visual analog scales (VAS) evaluating feelings of alertness and ability to concentrate. Measures were recorded on 100 mm scales, with 0 corresponding to 'not at all' and 100 corresponding to 'extremely' using computerized software (Adaptive VAS; Marsh-Richard et al. (2009).

Statistical Analysis

Analyses was conducted using SPSS Statistics, Version 21.0 (IBM Corp. 2012, Armonk, N.Y., USA). Initially, normality (Shapiro-Wilk test, p's>0.05) and sphericity (Mauchly's test) were examined. When assumptions of sphericity were breached, the Greenhouse-Geisser statistic was used. One-way repeated measures analysis of variance (ANOVA) was employed to determine if pre-trial conditions differed between treatments (i.e. BM and U_{SG}), fluid loss and fluid/nutrient intake. A series of 4 $(Treatment) \times 3$ (Time) repeated-measures ANOVAs were used to examine global CRT, CRT accuracy, the ex-Gaussian parameters (μ , σ and τ) and mood ratings. Pairwise comparisons (Bonferroni) were completed where significant main effects

were detected. Prior to analysing CRT data, all incorrect responses (n=76), correctresponses with CRT <200 ms (n=0) and correct responses with CRT >1000 ms (outliers) (n=6) were removed (Whelan, 2008). As a result, $\sim 2\%$ of the total data set was removed. Median CRT and response accuracy were then calculated for each set of stimuli and averaged by treatment and time point (Pre-Exercise, Post-Exercise, Post-Recovery). The Pre-Exercise CRT intra-class correlation coefficient (ICC) for was calculated via the two-way mixed average measures (absolute agreement) model; and the co-efficient of variation (CV) for Pre-Exercise CRT was calculated using the mean and SD. Effect sizes (ES) were calculated as Hedges' g (Hedges, 1981) using the spreadsheet by Lakens (2013). Ex-Gaussian parameters (μ , σ and τ) were obtained by employing the quartile maximum likelihood estimation procedure via QMPE 2.18 (Cousineau et al., 2004; Heathcote et al., 2002). All fits converged within 70 iterations. Statistical significance was accepted as $p \leq 0.05$. Data are reported as Mean±SD, unless otherwise indicated.

RESULTS

Exercise-Induced Dehydration

Pre-exercise values for BM and U_{SG} were similar across treatments (Table 1). All completed the same exercise protocol at each visit. For three individuals, the exercise duration was 70 min; while the remaining particiants cycled for 60 min. Gas exchange analysis indicated that participant's mean exercise intensity was 76±5% VO_{2max}. A 4 (Treatment) \times 6 (Time) analysis of HR data identified a main effect of time, F(1.8,12.5)=16.0, p<0.001, respectively. While a significant main effect of treatment was also observed, F(3,12)=3.21, p=0.044; pairwise comparisons did not identify any differences across trials (p's>0.05). BM loss did not differ significantly by treatment (Table 1) or trial order, F(3,21)=0.279, *p*=0.840.

Beverage and Nutrient Intake

Beverage intake did not differ by treatment, F(3,21)=1.15, *p*=0.351; or by trial order, F(3,21)=1.11, *p*=0.369 (Water: 852±279 g; SD: 1041±248 g; LS-MILK: 923±255

| | Water | SD | LS-MILK | HP-MILK | F | <i>p</i> -value |
|--|-----------------|-----------------|-----------------|-----------------|------------------|-----------------|
| $\begin{array}{l} \text{Pre-exercise} \\ U_{SG} \end{array}$ | 1.012 ± 0.005 | 1.014 ± 0.007 | 1.013 ± 0.005 | 1.014 ± 0.008 | F(3, 21) = 0.547 | 0.656 |
| Pre-exercise BM (kg) | 62.0 ± 10.8 | 61.7 ± 10.9 | 61.3 ± 10.5 | 61.6 ± 10.8 | F(3, 21) = 1.69 | 0.201 |
| BM loss (kg) | 1.2 ± 0.2 | 1.2 ± 0.2 | 1.2 ± 0.2 | 1.2 ± 0.1 | F(3, 21) = 0.151 | 0.928 |
| BM loss (%) | 2.0 ± 0.3 | 2.0 ± 0.4 | 2.0 ± 0.3 | 2.0 ± 0.3 | F(3, 21) = 0.388 | 0.763 |

Table 1Pre-trial conditions and exercise-induced dehydration

BM: Body mass; SD: Powerade[®] Isotonic; HP-MILK: Up&Go Energize[®]; LS-MILK: Up&Go Reduced Sugar [®]; U_{SG}: Urine specific gravity. Values are Mean±SD.

g; HP-MILK: 991±357 g). However, differences in total (i.e. food plus fluid) energy, F(1.4,10.2)=7.47, p=0.014; and CHO, F(3,21)=12.0, p<0.001; consumption were observed. Pairwise comparisons indicated that HP-MILK increased energy intake compared to Water (p=0.026) (Water: 2281±1205 kJ; SD: 3458±445 kJ; LS-MILK: 3978±1233 kJ; HP-MILK: 4297±946 kJ), and that Water decreased CHO intake, compared with all other treatments (p's<0.05) (Water: 66±33 g; SD: 113±18 g; LS-MILK: 117±22 g; HP-MILK: 124±27 g).

Cognitive Performance and Mood

Global CRT Performance. Pre-Exercise CRT, F(3,21)=1.51, p=0.242; and response accuracy did not differ by order of trials, F(3,21)=0.179, p=0.909; suggesting that learning was not an influential factor on cognitive performance results observed. An ICC of 0.96 (95% CI = 0.89–0.99, p<0.001) was calculated for Pre-Exercise CRT across

trials, indicating excellent reliability for this performance variable [31]. The degree of variability in participants' Pre-Exercise CRT across trials was calculated as a CV of 4.1%. A 4 (Treatment) × 3 (Time) analysis of median CRT identified a main effect of time, F(2,14)=8.4, p=0.004; with pairwise comparisons indicating a reduction in CRT Post-Exercise (401±48 ms), compared to Pre-Exercise (420 \pm 48 ms, p=0.025) and Post-Recovery (427 \pm 49 ms, p=0.050) (Figure 1). A 4 (Treatment) \times 3 (Time) analysis of response accuracy failed to indicate any main or interaction effects (p's>0.05). Participants demonstrated a high degree of accuracy (99±1%) in response to stimuli at all stages of testing.

Ex-Gaussian Modelling

A 4 (Treatment) \times 3 (Time) analysis of the ex-Gaussian parameter μ indicated a main effect of time, F(1.2,8.3)=8.13, p=0.018; with pairwise comparisons revealing a reduction in CRT Post-Exercise (366±47



Figure 1. The effect of exercise, dehydration and beverage consumption on global median CRT. Values are Mean±SEM. Water (•); SD (\circ); HP-MILK (**■**); LS-MILK (\Box); *a*, Post-Exercise significantly different from Pre-Exercise and Post-Recovery (*p*'s≤0.05).

ms), compared to Pre-Exercise (393±40, p<0.001) and Post-Recovery (395±52 ms, p=0.064) (Figure 2). The change in CRT Pre- to Post-Exercise was -29±27 ms (ES=0.57), -19±31 ms (ES=0.32), -25±25 ms (ES=0.35) and -37±20 ms (ES=0.63) on the Water, SD, LS-MILK and HP-MILK trials, respectively; indicating a relatively consistent small to moderate effect (Cohen, 1988). No other differences were observed (p's>0.05). No main or interaction effects were observed in 4 (Treatment) \times 3 (Time) analyses of σ - and τ -parameters (*p*'s>0.05). The whole CRT distribution is displayed in Figure 3.

Subjective Mood Ratings

No main or interaction effects were observed in 4 (Treatment) \times 3 (Time) analyses of alertness and concentration (*p*'s>0.05) (Figure 4).



Figure 2. The effect of exercise, dehydration and beverage consumption on the μ -parameter of the Gaussian CRT distribution. Values are Mean±SEM. Water (•); SD (\circ); HP-MILK (\blacksquare); LS-MILK (\square); *a*, Post-Exercise different from Pre-Exercise ($p \le 0.05$) and Post-Recovery (p < 0.010).



Figure 3. Kernal density plot of CRT at Pre-Exercise (solid red line), Post-Exercise (dashed green line) and Post-Recovery (dotted blue line)

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Figure 4. Subjective ratings of (A) alertness and (B) concentration. Values are Mean±SEM, where 0 mm represents *not at all* and 100 mm represents *extremely*. Water (•); SD (\circ); HP-MILK (\blacksquare); LS-MILK (\square). VAS: Visual Analog Scale.

DISCUSSION

This study observed a short-term performance-enhancing effect of acute aerobic exercise on CRT (response speed) in trained females, despite significant sweat loss (-2.0% BM loss). The effect was consistent across 4 separate trials that were standardized for exercise intensity and duration, energy expenditure (see companion paper: McCartney et al., 2019a), menstrual phase and level of dehydration. Ex-Gaussian analyses localized the improvement to the µ-component of the CRT distribution, suggesting that exercise improved participants' overall response speed, without affecting the variability or accuracy of responses. The cognitive benefit of exercise dissipated after a period of recovery (~1 h 45 min) with ad libitum consumption of different beverages and food.

In this study, CRT was significantly reduced ~5 min Post-Exercise, compared to Pre-Exercise values (-19±25 ms; ES=0.37).

The percentage of correct responses to choice reaction stimuli (CRT accuracy) was unchanged throughout trials. These results are consistent with Irwin et al. (2018) who observed a temporary improvement in CRT (-20±13 ms; ES=0.55) ~15 min Post-Exercise despite significant sweat losses (-2.5% BM loss) in trained male athletes. To the authors' knowledge, only two studies (Turner et al., 2017; Wong et al., 2014) have previously investigated the effect of a single bout of aerobic exercise on cognitive function in dehydrated females; and of these, only Turner et al. (2017) assessed CRT performance. Unlike the current study, this investigation, which involved 11 females of unknown training status, failed to detect a change in CRT pre- to postexercise with modest sweat losses (1.4% BM) (Turner et al., 2017). The contrasting result may relate to the timing of cognitive test administration, with the test battery used lasting \sim 45 min (i.e. concluding \sim 50 min post-exercise); by which time, any exercise-induced cognitive-effects may have dissipated [1-3]. Overall, findings from the current investigation and (Irwin et al. (2018)) suggest that the performanceenhancing effect of aerobic exercise on CRT in trained individuals is likely to outweigh any adverse effects imposed by dehydration (at levels $\leq 2.5\%$ BM loss) during the immediate post-exercise period. However, additional research is required to determine if this beneficial effect can offset impairment caused by dehydration in a more ecologically-valid context (e.g. during skillbased sporting events).

The ex-Gaussian analyses conducted in the current study localized the cognitive improvement to the µ-component of the CRT distribution. The magnitude of the effect on µ was relatively consistent across all 4 repeated trials (ES range: 0.32-0.63), indicating a small-moderate change (Cohen, 1988). To the authors' knowledge, only one study (Davranche et al., 2006) has previously characterized the effect of acute aerobic exercise on a reaction time distribution. Unlike the current study, this investigation evaluated CRT during exercise. Also, as testing began just 3 min after exercise commenced (and lasted <20 min), participants were unlikely to be in a state of significant fluid deficit. Despite this, results from the investigation are in keeping with the present study, indicating that acute aerobic exercise significantly reduced μ (-17 ms), without affecting the σ - or τ parameters of the ex-Gaussian distribution (Davranche et al., 2006). As such, distributional analysis investigations suggest that acute aerobic

exercise produces a positive effect on CRT, and that the effect is a result of a generalized improvement across the entire CRT distribution, i.e. exercise increases the participants overall response speed without affecting the spread or the skew of the CRT curve.

The performance-enhancing effect of aerobic exercise on CRT is thought to result from an increase in arousal (Chmura et al., 1998; Chmura et al., 1994). Fluid consumption has also demonstrated moodenhancing effects in dehydrated individuals (e.g. increased vigour and decreased fatigue) (McCartney et al., 2017). In contrast, dehydration may negatively impact moodstate (Masento et al., 2014). In this study, participants' subjective ratings of alertness and concentration were unchanged across trials. Thus, neither exercise, dehydration nor fluid consumption appeared to produce a dominant effect on mood. It is possible that any adverse effects imposed by dehydration were offset by a positive effect of exercise and/or fluid intake, such that the variables assessed were unchanged (Irwin et al., 2018).

A secondary aim of this study was to determine the effect of consuming different beverages and food *ad libitum* post-exercise on cognitive function. The *ad libitum* feeding approach was employed to increase the ecological validity of the recovery environment. While the Water treatment generally decreased energy and CHO consumption compared to the other beverages (as has been reported in other studies employing similar methodology

(Campagnolo et al., 2017; McCartney et al., 2019b), these differences did not significantly alter Post-Recovery mood or cognitive function. This finding contrasts prior evidence indicating that specific macronutrients (provided as small, prescribed amounts to fasted individuals) can differentially affect mood-state and cognitive function (Jones et al., 2012). Importantly, the current feeding protocol resulted in participants consuming large total macronutrient intakes, which varied according to the available beverage. Hence, it is possible that despite consuming less CHO and energy on the Water trial, the amounts consumed where sufficient to attenuate any differences in mood and cognitive function between trials during the post-recovery window. Alternatively, a larger participant sample may be required to detect a treatment effect. The sample size calculation in this study was performed to detect a significant effect of aerobic exercise on CRT, as limited research has examined the dietary behavior of females in the post-exercise period. Additional studies involving larger sample sizes are required to understand how the consumption of different beverages impact cognitive performance under real-life post-exercise conditions.

CONCLUSION

This investigation employed a novel, yet comprehensive, analysis approach to investigate the effect of acute dehydrating aerobic exercise on mood and CRT in trained females. Overall, results of the current study suggest that acute aerobic exercise provides a small but significant cognitive benefit to trained females during the immediate post-exercise period, even in the presence of significant sweat losses. The exercise-mediated effect was observed as a shift in the central (mean) response times, while the spread and skewness of the response distributions remained unchanged.

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Effect of Six-week Plyometric and Resistance Band Training on Badminton Overhead Clear Stroke in 12 Years Old Players

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ABSTRACT

This study examined the effect of plyometric and resistance band training on overhead clear stroke of 12 years old badminton players via a 6-week intervention comprising plyometric and resistance band training sessions. The participants were ninety players (age, 12 years; height, 1.4-1.5m; body mass 30-40kg) comprised of 3 groups; plyometric training (n=30), resistance band training (n=30) and control group (n=30). The players completed the plyometric and resistance band training sessions. The badminton overhead clear stroke performance test (Onn, 1993) was conducted on 3 groups before and after the 6-weeks training. An ANCOVA was used to determine the changes between conditions and revealed the plyometric training significantly improved badminton overhead clear stroke (p < 0.05); pre: 5.20±0.49, post: 7.30±0.50 compared with resistance training (p <(0.05); pre: 5.21 ± 0.31 , post: 6.57 ± 0.36 and control group (p < 0.05); pre: 5.22 ± 0.29 , post: 5.37 ± 0.30 . Although both experimental groups demonstrated a significant improvement as compared to the control group, the plyometric group showed a significant improvement as compared to the resistance group. Findings showed that 6 weeks of plyometric training was more effective compared with resistance band training in improving the performance of badminton overhead clear stroke.

Keywords: Badminton overhead clear stroke, plyometric, resistance training

INTRODUCTION

Badminton is a racket sport which needs power and agility in leaps, veers and quick arm movements. Most young players do not have enough ability to produce power, agility and quick arm movements. Badminton is a game played with rackets and shuttlecocks. One of the most important

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ISSN: 0128-7702 e-ISSN 2231-8534 strokes in badminton is the overhead stroke (Zhang et al., 2016). All the overhead forehand strokes movement have similarity except trajectory of the shuttlecock and strength while hitting the shuttlecock (Brahms, 2014). The overhead forehand stroke is played with full, throwing motion from the back half of the court. Forearm pronation important in forehand stroke. The forehand overhead stroke is probably the most powerful aspect of a player's game. You may use it as an offensive or defensive shot to move the opponent into back court and let the opponent to return a weak stroke (Zhang et al., 2016).

High and deep clear is usually use to gain time to return to the centre court position. It is often the recommended strategy especially in singles' play. While playing doubles', defensive clear is more recommended. The defensive clear is a high trajectory return similar to the lob in tennis. The tactical approach of the clear is to move the shuttle away from the opponent that would move him or her around the back court. By getting the shuttlecock behind the opponents or making them move more quickly than they would like, they will have less time to react and become more fatigued easily that forces weak returns. In addition, the clear can be defensive shot as it has a high and deep trajectory (Zhang et al., 2016).

Plyometric exercises which have to be perform explosively can be adapted more specific as well as mimic the throwing motion such as overhead clear stroke, overhead smash (badminton) and serve (tennis) in terms of movement similarity (Behringer et al., 2013). The utilisation of plyometric in training is found to gain an upper-edge in badminton-specific skills, patterns in movement such as jump, run and muscle-physiological changes which can improve the jump and speed performance (Joshi, 2012; Kansas, 2012). In addition, resistance band exercises have been utilised as a training method that can improve muscles strength and functional performance in sport specific skills (Treiber et al., 1998).

The study investigated the effectiveness of plyometric versus resistance band training on overhead clear stroke of 12 years old players. To date, there is no studies that examine the effect of plyometric training on puberty young children in sports-specific skills in badminton although numerous studies have examined physical components of different sports such as gymnastics (Bogdanis et al., 2019), soccer (Hammani et al., 2016), badminton (Irawan, 2017) and handball (Chelly et al., 2014). Therefore, the rationale of the study was to examine whether these two types of training methods would be able to improve the explosive movements of the young players in executing their badminton overhead clear stroke.

METHOD

Participants

A total of ninety players (36 males and 54 females) from a Chinese school located in Selangor, Malaysia participated in this study.

Permission was granted by their parents and the school's headmaster. In this study, the subjects involved were intact group of 12 years old students. Three classes of 12 years old students were involved in this study. All the first class of students were chosen for experimental group 1(plyometric training group), while as the second class of 12 years old students were chosen for experimental group 2 (resistance band training group) and the third class of 12 years old students were chosen for control group.

Experimental Design

The quasi-experimental design was used to compare the effectiveness of the plyometric training and elastic band training on badminton overhead clear stroke among year six students. The intact grouping method was selected due to quasi-experimental nature of the study design. According to Daniel (2011), an intact sampling method is a form of nonprobability sampling method that yields result and can be generalized after making strong assumptions regarding sample. The chosen subjects were divided into three groups which are experimental group (plyometric training group and resistance band training group) and control group. The plyometric exercises were selected based on their similarity to badminton movement, level, volume and intensity of the players.

Training Intervention

The plyometric and resistance band exercises were adapted according to Brittenham (1992) guide lines based on the principles of progression, specificity and overload.

Plyometric training has been used to improve badminton overhead clear stroke. Sets of 3 with 20 repetition of shuttlecock throwing and 3 sets with 12 repetition of jumping lunges were conducted in the first week during plyometric training (Table 1). Starting from 2nd week until 4th week, participants would go through 2kg medicine ball shoulder throw (3 sets x 12 repetition)

| Table 1 | |
|------------|----------|
| Plyometric | training |

| Week | Training 1 | Training 2 |
|--------|---|-------------------------------|
| Week 1 | Shuttlecock throwing (3 sets x 20) | Jumpinglunge (3 sets x 12) |
| Week 2 | Dominant hand medicine ball shoulder throw (2kg) (3 sets x 12) | Jumping lunge (3 sets x 12) |
| Week 3 | Dominant hand medicine ball shoulder throw (2kg) (3 sets x 12) | Jumping lunge (3 sets x 12) |
| Week 4 | Dominant hand medicine ball shoulder throw (2kg) (3 sets x 12) | Jumping lunge (3 sets x 12) |
| Week 5 | Dominant hand medicine ball shoulder throw (4kg) (3 sets x 12) | Jumping lunge (3 sets x 12) |
| Week 6 | Dominant hand medicine ball shoulder throw (4kg) (3 sets x 12) | Jumping lunge (3 sets x 12) |

| Table 2 | | |
|------------|------|----------|
| Resistance | band | training |

| Week | Training 1 | Training 2 |
|--------|--|--|
| Week 1 | 3 sets x 12 of shoulder internal and external rotation exercises (6lbs of yellow resistance band) | 3 sets x 12 squad (6 lbs resistance band) |
| Week 2 | 3 sets x 12 shoulder internal and external rotation exercises (6 lbs of yellow resistance band) | 3 sets x 12 squad (6 lbs resistance band) |
| Week 3 | 3 sets x 12 shoulder internal and external rotation exercises (6 lbs of yellow resistance band) | 3 sets x 12 squad (6 lbs resistance band) |
| Week 4 | 3 sets x 12 shoulder internal and external rotation exercises (9 lbs of green resistance band) | 3 sets x 12 squad (9 lbs resistance band) |
| Week 5 | 3 sets x 12 shoulder internal and external rotation exercises (9 lbs of green resistance band) | 3 sets x 12 squad (9 lbs resistance band) |
| Week 6 | 3 sets x 12 shoulder internal and external rotation exercises (9 lbs of green resistance band) | 3 sets x 12 squad (9 lbs resistance band) |

and jumping lunges (3 sets x 12 repetition) during plyometric training. From 5th week until 6th week, participants would go through 4kg medicine ball shoulder throw (3 sets x 12 repetition) and jumping lunges (3 sets x 12 repetition) during plyometric training.

In resistance band training, starting from 1st week until 3rd week, participants would go through internal and external rotation exercises with 6lbs of yellow resistance band (3 sets x 12 repetition) and squat using 6lbs of yellow resistance band (3 sets x 12 repetition) (Table 2). From 4th week until 6th week, participants would go through internal and external rotation exercises with 9lbs of green resistance band (3 sets x 12 repetition) and squat using 9lbs of green resistance band (3 sets x 12 repetition).

Control Group Training

In control group training, all the12 years old players followed the normal physical education class. All players followed through physical education class for 6 weeks.

Badminton Overhead Clear Test

Standard badminton courts were used for test of overhead clear. During the pre-test and post-test, every player went through five times of attacking overhead clear test. Shuttlecock feeding started by the feeder from centre of opposite court to the participant. Every clear shot hit by the participant landed on the score area would be counted. There are three types of score which were 1, 2 and 3 based on areas that shuttlecock landed.

Statistical Analysis

The test for badminton overhead clear, Onn (1993) was used to evaluate the performance of overhead clear stroke among 90 participants during pre-test and post-test (Figure 1). All participants were required to go through this test during pre-test and post-test. Three attempts were given to every participant to hit the overhead clear. Each trial has three types of scores which are one, two and three. These

Plyometric and Resistance Band Training on Badminton Overhead Clear Stroke



Figure 1. Test for overhead clear. Adapted from Onn (1993)

scores would be recorded after every clear stroke hit by the particular participant. Pretest would be conducted in the first week followed by six weeks of plyometric training (experimental group 1), resistance band training (experimental group 2) and control group. Post-test has been conducted during the last week. After the post-test, the data has been collected.

RESULTS

The experimental group (plyometric training) showed significant improvement as compared to experimental groups (resistance band training) and the control group in the badminton overhead clear assessment.

Experimental 1 (Plyometric Training) vs Experimental 2 (Resistance Band Training)

Table 3 shows Levene's test of homogeneity of variance. Based on the table, the data from experimental group 1 and experimental group 2 were homogeneous (F=0.314, sig=0.578). According to Hair et al. (2010) if the significant is >0.05 the data is homogeneous.

Table 3

Levene's test of equality of error variances

| F | df1 | df2 | Sig. |
|-------|-----|-----|-------|
| 0.314 | 1 | 58 | 0.578 |

Table 4Descriptive statistics

| Group | Ν | Mean | Std. Deviation |
|--------------|----|------|----------------|
| Experiment 1 | 30 | 7.30 | 0.952 |
| Experiment 2 | 30 | 6.57 | 1.104 |
| Total | 60 | 6.93 | 1.087 |

Table 4 shows the descriptive analyses on post-test for experimental group 1 and experimental group 2. Based on the table, the mean scores and standard deviation of post-test for experimental group 1 was 7.30 and 0.952 respectively. While the mean score and standard deviation of post-test for experimental group 2 was 6.57 and 1.104 respectively. The results revealed the mean score of post-test for experimental group 1 was higher than mean score of post-test for experimental group 2 after treatment.

The ANCOVA results in Table 5 showed a significant difference in the achievement on functions between the experiment 1 and experiment 2 groups, with the pre-test as the covariate (F(1,57)=41.571, sig= 0.000, p<0.05). The participants in the experiment 1 group (mean=7.30) showed higher scores than experiment 2 group (mean= 6.57) (Table 4), which meant that the use of plyometric training had better effect on participants' achievement on badminton overhead clear than the resistance band training. The differential effect is small (partial eta square =0.001) (Cohen, 1988).

| Source | Type III Sum of Squares | DF | M^2 | F | Sig. | η^2 |
|-----------------|-------------------------|----|--------|--------|-------|----------|
| Corrected Model | 34.074a | 2 | 17.037 | 27.232 | 0.000 | 0.489 |
| Intercept | 9.315 | 1 | 9.315 | 14.889 | 0.000 | 0.207 |
| Pre-Score | 26.007 | 1 | 26.007 | 41.571 | 0.000 | 0.422 |
| Group | 0.031 | 1 | 0.031 | 0.049 | 0.826 | 0.001 |
| Error | 35.660 | 57 | 0.626 | | | |
| Total | 2954.000 | 60 | | | | |
| Corrected Total | 69.733 | 59 | | | | |

Experimental 1 (Plyometric Training) vs Control Group

Table 6

Table 5

Tests of between-subjects effects

Levene's test of equality of error variances

| F | dfl | df2 | Sig. |
|-------|-----|-----|-------|
| 0.495 | 1 | 58 | 0.484 |

Table 6 shows Levene's test of homogeneity of variance. The results showed that experimental 1 and control group were homogeneous (F=0.495, sig=0.484). According to Hair et al. (2010) if the significant is>0.05 the data is homogeneous.

Table 7 shows the descriptive analyses on post-test for experimental group 1 and control group. Based on the table, the mean scores and standard deviation of post-test for experimental group 1 was 7.30 and 0.952 respectively. The mean score and standard deviation of post-test for control group was 5.37 and 0.669 respectively. The results revealed the mean score of post-test for experimental group 1 was higher than mean score of post-test for control group after treatment.

| Table 7 | |
|-------------|------------|
| Descriptive | statistics |

| Group | N | Mean | Std. Deviation |
|--------------|----|------|----------------|
| Experiment 1 | 30 | 7.30 | 0.952 |
| Control | 30 | 5.37 | 0.669 |
| Total | 60 | 6.35 | 1.260 |

The ANCOVA results in Table 8 showed a significant difference in the achievement on functions between the experiment 1 and control groups, with the pre-test as bi-covariate (F(1,57)= 13.602, sig= 0.001, p<0.05). The participants in the experiment 1 group (7.30 ± 0.952) showed higher achievement than control group (5.37 ± 0.669) (Table 7), which meant that the use of plyometric training had better effect on participants' badminton overhead clear than the training in-control group had. Such a differential effect is small (partial eta square =0.348) (Cohen, 1988).

Table 8Tests of between-subjects effects

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | η^2 |
|-----------------|-------------------------|----|-------------|--------|-------|----------|
| Corrected Model | 64.882ª | 2 | 32.441 | 64.277 | 0.000 | 0.693 |
| Intercept | 12.297 | 1 | 12.297 | 24.365 | 0.000 | 0.299 |
| Pre-Score | 6.865 | 1 | 6.865 | 13.602 | 0.001 | 0.193 |
| Group | 15.339 | 1 | 15.339 | 30.392 | 0.000 | 0.348 |
| Error | 28.768 | 57 | 0.505 | | | |
| Total | 2513.000 | 60 | | | | |
| Corrected Total | 93.650 | 59 | | | | |

Experimental 2 (Resistance Band Training) vs Control Group

Table 9

Levene's test of equality of error variances

| F | df1 | df2 | Sig. |
|-------|-----|-----|-------|
| 0.973 | 1 | 58 | 0.328 |

Table 9 shows Levene's test of homogeneity of variance. The resulted showed that the experimental 2 group and control group are homogeneous (F=0.973, sig=0.328). According to Hair et al. (2010) if the significant is >0.05 the data is homogeneous.

Table 10Descriptive statistics

| Group | N | Mean | Std. Deviation |
|--------------|----|------|----------------|
| Experiment 2 | 30 | 6.57 | 1.104 |
| Control | 30 | 5.37 | 0.669 |
| Total | 60 | 5.50 | 0.813 |

Table 10 showed the descriptive analyses on post-test for experimental group 2 and control group. Based on the table, the mean scores and standard deviation of post-test for experimental group 2 was 6.57 and 1.104 respectively. While the mean score and standard deviation of posttest for control group was 5.37 and 0.669 respectively. The results showed that the mean score of post-test for experimental group 2 was higher than mean score of posttest for control group after treatment.

The ANCOVA results in Table 11 showed a significant difference in the achievement on functions between the experiment 2 and control groups, with the pre-test as the covariate (F(1,57)= 8.122, sig= 0.000, p<0.05). The participants in the experiment 2 group (6.57 ± 1.104) showed

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | η^2 |
|-----------------|-------------------------|----|-------------|--------|-------|----------|
| Corrected Model | 9.188ª | 2 | 4.594 | 8.784 | 0.000 | 0.236 |
| Intercept | 9.542 | 1 | 9.542 | 18.245 | 0.000 | 0.242 |
| Pre-Score | 8.122 | 1 | 8.122 | 15.529 | 0.000 | 0.214 |
| Group | 0.894 | 1 | 0.894 | 1.710 | 0.196 | 0.029 |
| Error | 29.812 | 57 | 0.523 | | | |
| Total | 1854.000 | 60 | | | | |
| Corrected Total | 39.000 | 59 | | | | |

| Table I | 1 | |
|----------|------------------|---------|
| Tests of | between-subjects | effects |

higher achievement than control group (5.37 ± 0.669) (Table 10), which meant that the use of resistance band training had better effect on participants' badminton overhead clear than the training in control group had. Such a differential effect is small (partial eta square =0.029) (Cohen, 1988).

DISCUSSION AND CONCLUSION

The results showed that plyometric training could help to enhance the performance of the badminton players in the overhead clear stroke. This implied that normal badminton training alone would not enable the players to have significant changes in their strokes performance. In addition, it can also improve the overhead smash stroke or tennis serve in tennis which has similar intermuscular coordination from the lower to the upper body and then to the shuttlecock or ball through a kinetic chain (Fernandez-Fernandez et al., 2016).

The results showed that experimental group 1 had a higher mean than experimental group 2 and followed by control group. The finding was consistent with previous study which found that plyometric training was one of the best methods to increase explosive power (Radcliffe & Farentinos, 2015). Plyometric training shows positive results to most sports such as football, karate, handball, badminton and tennis (Brito et al., 2012; Chelly et al., 2014; Fernandez-Fernandez et al., 2016; Middleton et al., 2016; Salonikidis & Zafeiridis, 2008). In addition, it can improve and influence the vertical power of the players on badminton techniques such as overhead clear stroke smashes (Fröhlich et al., 2014; Kannas et al., 2012). Players need the higher power of muscles in order to perform a good quality badminton overhead clear stroke. Power is just as dependent upon speed as it is force. It is synonymous with speed-strength or explosive strength. Therefore, strength plus speed equal to power. Plyometric training is a method which train both strength and speed to generate greater power in muscles. We can conclude that plyometric training is better method to improve badminton overhead clear strokes than elastic band training method.

In Ellenbecker and Roetert (2004) study, elastic band had been used to strengthen shoulder's muscles in tennis serves. Tennis serve and badminton overhead stroke have same motion as throwing action. The results showed that elastic band training also improved the badminton overhead clear stroke. However, plyometric training proved to be more effective in increasing strength in which badminton strokes require explosive power to produce powerful and effective strokes. Whereas, resistance band training has slightly lower mean score than plyometric training because the resistance band training focuses more on shoulder muscles. Resistance band also focuses on strength training compare to plyometric training which focuses on strength and speed.

According to Zhang et al. (2016), powerful throwing comes from all body segments that produce maximal absolute velocity to your dominant hand and transfer the energy into your racket in one smooth movement. In plyometric training, a complete movement of throwing action apply during training session. This training would produce a powerful throwing movement that comes from all body segments that produce maximal absolute velocity to your dominant hand and transfer the energy into your racket in one smooth movement. Elastic band training focuses on strengthening shoulder muscles but other part of the body movements have been restricted. The results proved that plyometric training have positive effects on their jump heights, reach, racquet-head speed and stability of the players in executing their strokes. This implied that plyometric movements that mimic the badminton overhead clear stroke would improve the performance of the young badminton players.

The implementation of plyometric training that mimic sport-specific skills and progressively in the normal training programs is important as it can lead to specific athletics quality enhancements in terms of explosive actions in badminton. The study was limited to young adolescent players, and future studies should look into the combination of both plyometric training and elastic band training to other ethnicities, age groups and competitive levels of the athletes.

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Adolescent Athletes' Expectancy Beliefs, Task Values and Types of Motivation in Sports

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ABSTRACT

This study examined adolescent athletes' expectancy-beliefs, subjective task values, intrinsic motivation, extrinsic motivation and amotivation in sports. Two hundred and five athletes (131 males and 74 females) below 21 years old (15.53 + 2.37) completed the expectancy beliefs, subjective task values measures and the Sports Motivation Scale questionnaire. The two-way ANOVA results indicated a significant interaction effect between age group, and gender, for expectancy beliefs, and age group, for subjective task values in the expectancyrelated beliefs and task values measures. Whereas, for the Sports Motivation Scale, the ANOVA results also showed significant interaction effect between age group and gender for intrinsic motivation as well as age group and gender for extrinsic motivation. However, no significant effect was observed between age, gender and locality was found for amotivation. Expectancy-related beliefs were found to be related with subjective task values (r = 0.78) and intrinsic motivation (r = 0.58). Whereas, subjective task values were moderately correlated with intrinsic motivation (r = 0.65) and extrinsic motivation (r = 0.54). Intrinsic motivation was related to extrinsic motivation (r = 0.83) but weakly with amotivation (r= 0.20). The results concluded that adolescent athletes (young generation) showed a trend of higher self-beliefs and values were also more likely to be intrinsically and extrinsically motivated, a combination of both types of motivation as opposed to earlier literature of

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ISSN: 0128-7702 e-ISSN 2231-8534 single motivation type. In addition, our results support the relationship in combining Eccles et al. (1993) Expectancy Theory and Self-Determination Theory to improve understanding of motivation in sports.

Keywords: Adolescent athletes, amotivation, beliefs, extrinsic motivation, intrinsic motivation, task values

INTRODUCTION

The understanding between motivation and behaviour utilising the Eccles et al. (1993)'s expectancy-value of achievement choice and self-determination theory (Deci & Ryan, 1985), have provided a deeper insight into the reasons concealing individuals' participation in physical activities and sports. The Eccles et al. (1993)'s expectancy-value theory refers to motivated behaviour that is characterised by voluntary choices, persevering effort, and achievement, which are related with one's perceived expectancy of success and values in certain activities (Ryan & Deci, 2000). The achievement-beliefs and behaviours are influenced by expectancies for success, i.e. self-beliefs about being successful at a task. For example, athletes' evaluation of their ability in different tasks during training and their sense of performance in their tasks. Whereas, the subjective task values refer to the perceived value a task may provide for present and future goals (Grasten, 2016) in which the values are placed by an individual on their success in a domain or task. The task values are attainment, intrinsic, utility and cost (Chin et al., 2009).

The innate satisfaction of the three basic psychological needs of competence, autonomy and relatedness of an individual that resides along a continuous sequence that runs from a non-self-determined to self-determined form of motivation (Ryan & Deci, 2000; Wang et al., 2019; Ratelle et al., 2007, Vallerand, 1997). Intrinsic motivation is engaging in exciting, enjoyable activities which offer the opportunity for learning in an individual that represents the highest form of motivation. Whereas, extrinsic motivation is regulated by external forces in the forms of rewards or avoiding negative consequences (Byran & Solmon, 2007). The lack of motivation or desire to act is known as amotivation (Ryan & Deci, 2000). Favorable behavior and performance such as concentration and effort are related with higher intrinsic level of motivation which is derived from the enjoyment and satisfaction within oneself (Byran & Solomon, 2007).

The socio-demographic factors that influence athletes' perceptions beliefs, task values and self-determination are gender, age and locality. Studies have shown that males have higher expectancy-beliefs than females in sports activities and physical education (Chin et al., 2009; Dawes, 2014; Fredricks & Eccles, 2002; Gao & Xiang, 2008; Grasten, 2016; Xiang et al., 2003; Yli-Piipari et al., 2013). In addition, males also show higher task values than female in sports and physical education (Chow et al., 2012; Eccles et al., 1993; Fredricks & Eccles, 2002; Klomsten et al., 2005; Pang & Sau, 2010). However, other studies examining children reveal no male and female differences in beliefs in physical education, running program, basketball and school sports whereby the boys and girls view these activities as relevant and suitable for male and female (Fredricks & Eccles, 2002; Gao & Xiang, 2008; Jacobs & Eccles, 2000; Xiang et al., 2006; Xiang et al., 2004; Xiang et al., 2003).

Gender differences are also observed in athletes' self-determination profile in which female showed higher intrinsic form of motivation than males in physical education and sports (Gillet et al., 2012; Monazami et al., 2012). A number of studies has shown that male athletes who are extrinsically motivated are more likely to emphasize on extrinsic factors as compared to intrinsicallymotivated female athletes centred on the mastery of task and enjoyment (Jakobsen & Evjen, 2018; Martinovic et al., 2011; Teo et al., 2015). On the contrary, males are shown to have higher levels of intrinsic motivation than females (Afsanepurak et al., 2012; Egli et al., 2011; Teo et al., 2015) and no differences between both gender in their participation in sports (Kline, 2016; Van Heerden, 2014).

Literature has also revealed that there are also differences in children's expectancy-related beliefs and values across age whereby their beliefs and values tend to decline as they mature. Studies have shown that children's expectancy-beliefs on their own abilities and expectancy of success are more positive and confident when they feel capable and competent which lead to better performance on future tasks (Gao & Xiang, 2008; Wigfield & Eccles, 2002; Xiang et al., 2003; Xiang et al., 2004). However, as children age, their expectancy-related beliefs become more realistic with the performance in terms of success or failure expectations (Wigfield & Eccles, 2002). Studies have also shown that task values towards physical education and school sports decline across the elementary and middle schools (Fredricks & Eccles, 2002; Wigfield et al., 1996). In contrast, Xiang et al. (2006) revealed that the children's expectancy-related beliefs and task values had declined across age in their study.

Studies that look into age and motivation found contrasting results on motivation among younger and older students. Gillet et al., (2012) found a decrease in intrinsic motivation from 9 years old to 12 years old children and slowly stabilized when they reached 15 years old among 1600 students of age groups 9 - 17 years. In a separate study, younger students were more intrinsically motivated than older students in their involvement in physical education (Biddle et al., 1999; Digelidis & Papaioannou, 1999). Conversely, younger athletes have shown to be less intrinsically and extrinsically motivated than older athletes (Chin et al., 2016). This is supported by Mladenovic and Marjanovic (2011) study which showed amotivation was much prominent among 12 year old football players and 13 - 14 year old players were more extrinsically motivated as compared to the other age groups.

Few empirical studies have looked at expectancy-related beliefs, values and motivation based on locality. Athletes in the rural areas showed higher task values than urban athletes (Chin et al., 2009). In addition, rural and urban young female athletes have higher task values as compared to the male athletes (Chin et al., 2009). In contrast, urban athletes tend to show higher intrinsic motivation than rural athletes as they can get access to sports facilities, equipment, funding, sports-science services and support from all stake holders in sports (Chin et al., 2012). Furthermore, McHale et al. (2005) revealed that participation in sports provided an optimistic impact on

self-confidence and social competence among urban school children. The urban school youth engagement in sports have positively influenced their self-esteem and social competence (McHale et al., 2001; Tylor et al. 2010). The deprivation of sports facilities, equipment, resources, opportunities, supports, funding, economic constraints and lack of opportunities due to its location have demotivated the rural athletes in terms of their outcome and accomplishment in sports (Hardre et al., 2007). This study aimed to investigate adolescent athletes' expectancy-related beliefs, task values of attainment, utility, interest and types of motivation across gender, age groups and locality. In addition, it aimed to investigate whether expectancyrelated beliefs, task values are related to intrinsic motivation, extrinsic motivation and amotivation. The rationale of the study is to help the coaches, sports organizations and authorities to further understand, assess and design intervention programmes that can strengthen and improve the athletes' motivation and performance.

METHOD

Participants

The participants comprised 205 (males=131, females=74) under-21 elite Sarawak athletes competing in the 16th Malaysian Games. Permission were obtained from the State Sports Council, State Education Department and National Sports Associations. This research was approved by the Ethics Committee of University Malaya (UM. TNC2/RC/H&E/UMREC-40).

Data Collection

The questionnaires were administrated to all the participants during the games' centralized camp. The researcher briefed the participants on the nature of the study and their participation were voluntary whereby their consents were obtained and assured of their confidentiality. Participants were briefed on their right to withdraw from the participating in the study without any consequences.

The Eccles et al. (1993)'s expectancy value questionnaire is an eleven items questionnaire designed to assess the ability beliefs, expectancy for success, attainment value, utility value and interest value which had been utilized in the physical education and sports domains (Chin et al., 2009; Gao & Xiang, 2008; Xiang et al., 2004). This measure consists of two subscales i.e., expectancy-related beliefs and expectancy for success (5 items) and subjective task values (6 items). Both subscales were measured on a 7-point Likert type scale anchored at both ends. Both expectancy-related beliefs, subjective task values sub-scales and overall questionnaire demonstrated high internal consistency with alpha reliability coefficients of 0.81 and 0.82 and 0.88 respectively (Chin et al., 2009). The 28-item Sport Motivation Scale (SMS) was developed by Pelletier et al. (1995) based on the framework of the self-determination theory which measured intrinsic motivation, extrinsic motivation, and amotivation. The SMS has 7 sub-scales with 4 items each. Each item is scored on a 7-point Likert scale ranging from 1 (does not correspond at all) to 7 (corresponds exactly). The SMS internal consistency and validity were found to be good in the physical education and sports domains (Chin et al., 2012; Ratelle et al., 2007; Sebire et al., 2013). In addition, Teo et al. (2015) study on Malaysian's adolescent ten-pin bowlers demonstrated favorable internal consistency of 0.74 to 0.80 for all the subscales.

RESULTS

Table 1 shows that all the questionnaires demonstrated good reliabilities for all its scales. The overall expectancy beliefs and task values scale (EVTV) showed a good internal consistency of 0.93 while subscales alpha coefficients for the expectancyrelated beliefs ($\alpha = 0.89$) and subjective task values ($\alpha = 0.90$) were high which were more than the required alpha of 0.7

Table 1

Internal Consistency of expectancy beliefs, task values and sports motivation scale

| Scale | Cronbach's |
|---|------------|
| | Alpha |
| Overall Expectancy beliefs and task value questionnaire | 0.93* |
| Expectancy Beliefs | 0.89* |
| Subjective Task values | 0.90* |
| SMS | |
| Overall SMS questionnaire | 0.91* |
| Intrinsic Motivation (IM) | 0.88* |
| IM to Know | 0.75* |
| IM Experience Situation | 0.66 |
| IM to Accomplish | 0.71* |
| Extrinsic Motivation (EM) | 0.87* |
| EM External Regulation | 0.71* |
| EM Introjection | 0.67 |
| EM Identification | 0.80* |
| Amotivation | 0.65 |

(George & Mallery, 2003). The full SMS, intrinsic motivation and extrinsic motivation subscales demonstrated high reliability of 0.91, 0.88 and 0.87 with a slightly low reliability for amotivation subscale with α value of 0.65 which was retained to measure amotivation which was an integral part of motivation.

The data in Table 2 show the sociodemographic profile of participants. A total of 205 athletes (male=131, female=74, M = 15.53 ± 2.37) were involved in this study. Forty-seven percent of the sample was <15 years old. A third of the sample were Malays and Ibans. Almost 26% of the participants had < 3 years of experience while 27.3% had 3 - 4.9 years of experience and 29.3% had 5-6.9 years of experience. Most participants were state athletes (58.5%). Nineteen percent of the athletes represented the district and 18% played for division. Only a small number of the athletes (4.4%) represented the nation. Almost 88% of the participants (n=180) were high school students, 7.3% was undergraduate (n=15) while about 5% was working adolescents (n=10). Sixty percent (n=123) of the participants were from the urban areas with the majority (52.7%) coming from Kuching.

Table 3 showed the ANOVA for expectancy beliefs, task values and types of motivation based on age groups, gender and locality. The ANOVA analysis for expectancy-related beliefs showed that there were significant main effects for age group (F(1, 197) = 6.47, p < 0.05) and gender (F(1,197) = 12.97, p < 0.05) but no significant main effect of locality (F(1,197))

Table 2Profile of the participants

| Characteristics | | N | % |
|-----------------|-------------|----------------|-------|
| Gender | Male | 131 | 63.9% |
| Female | | 74 | 36.1% |
| Age group | | 15.53 ± 2.37 | |
| (year) | <15 yrs | 97 | 47.3% |
| | >15 yrs | 108 | 52.7% |
| Race | Iban | 67 | 32.7 |
| | Bidayuh | 28 | 13.7 |
| | Chinese | 22 | 10.7 |
| | Malay | 72 | 35.1 |
| | India | 7 | 3.4 |
| | Other races | 9 | 4.4 |
| Years of | 0-2.9 yrs | 53 | 25.9% |
| competing | 3-4.9 yrs | 56 | 27.3% |
| | 5-6.9 yrs | 60 | 29.3% |
| | 7-8.9 yrs | 31 | 15.1 |
| | >9 yrs | 5 | 2.4% |
| Level of | District | 39 | 19% |
| competition | Division | 37 | 18% |
| | State | 120 | 58.5% |
| | Country | 9 | 4.4% |
| Type of | Secondary | 180 | 87.8 |
| school | IPG/IPT | 15 | 7.3 |
| | Working | 10 | 4.9 |
| Locality | Urban | 123 | 60.0 |
| | Rural | 82 | 40.0 |
| Town | Kuching | 108 | 52.7 |
| | Sri Aman | 11 | 5.4 |
| | Sibu | 14 | 6.8 |
| | Miri | 6 | 2.9 |
| | Lambang | 7 | 3.4 |
| | Sarikei | 4 | 2.0 |
| | Kapit | 7 | 3.4 |
| | Samarahan | 38 | 18.5 |
| | Bintulu | 3 | 1.5 |
| | Mukah | 2 | 1.0 |
| | Betong | 5 | 2.4 |

=1.52, p > 0.05). However, There were no significant differences for age x gender (*F*(1, 197) = 1.67, p > 0.05, partial $\eta 2 = 0.008$), age x location (*F*(1, 197) = 1.84, p > 0.05, partial $\eta 2 = 0.003$), gender x locality (*F*(1, 197) = 0.52, p > 0.05, partial $\eta 2 = 0.008$). In

addition, there was no significant interaction between age x gender x locality (F(1, 197)= 0.09, p > 0.05, partial $\eta 2 = 0.001$).

The ANOVA analysis for subjective task values showed that there were significant main effects for age group (F(1,197) = 7.33, p < 0.05) but not significant for gender (F(1, 197) = 3.50, p < 0.05) and locality (F(1,197) = 1.73, p > 0.05) main effect. The result also showed no significant interaction between age x gender (F(1, 197) = 1.34, p > 0.05, partial $\eta 2 = 0.007$), age x location (F(1, 197) = 2.18, p > 0.05, partial $\eta 2 = 0.005$, partial $\eta 2 = 0.005$, partial $\eta 2 = 0.006$). Furthermore, no significant interaction effect was shown on age x gender x locality (F(1, 197) = 1.27, p > 0.05, partial $\eta 2 = 0.006$). Furthermore, no significant interaction effect was shown on age x gender x locality (F(1, 197) = 0.70, p > 0.05, partial $\eta 2 = 0.004$).

The ANOVA analysis for intrinsic motivation revealed that there were significant main effects for age group (F(1,197) = 9.15, p < 0.05), gender, (F(1,197) = 10.56, p < 0.05) but no significant main effect for locality (F(1,197) = 0.20, p >0.05). There was no significant interaction between age x gender (F(1, 197) = 1.29, p> 0.05, partial $\eta 2 = 0.007$), age x location $(F(1, 197) = 0.05, p > 0.05, partial \eta 2 =$ 0.001), gender x locality $(F(1, 197) = 0.17, p > 0.05, partial <math>\eta 2 = 0.001$). There was also no interaction effect for age x gender x locality $(F(1, 197) = 0.03, p > 0.05, partial \eta 2 = 0.001)$.

The ANOVA analysis for extrinsic motivation showed significant main effects for age group (F(1,197) = 6.96, p < 0.05), gender (F(1, 197) = 11.52, p < 0.05) but insignificant main effect for locality

Table 3

| Variable | df | MnSq | F | Sig. | η^2 |
|-------------------------|----|-------|-------|-------|----------|
| Expectancy Belief | | | | | |
| Age | 1 | 10.73 | 6.47 | 0.00* | 0.062 |
| Gender | 1 | 5.35 | 12.97 | 0.01* | 0.032 |
| Location | 1 | 1.26 | 1.52 | 0.22 | 0.008 |
| age x gender | 1 | 1.38 | 1.67 | 0.20 | 0.008 |
| age x location | 1 | 0.43 | 1.84 | 0.47 | 0.003 |
| gender x location | 1 | 1.52 | 0.52 | 0.18 | 0.009 |
| age x gender x location | 1 | 0.08 | 0.09 | 0.76 | 0.000 |
| Subjective Task Values | | | | | |
| Åge | 1 | 7.16 | 7.33 | 0.01* | 0.036 |
| Gender | 1 | 3.41 | 3.50 | 0.06 | 0.017 |
| Location | 1 | 1.69 | 1.73 | 0.19 | 0.009 |
| age x gender | 1 | 1.31 | 1.34 | 0.25 | 0.007 |
| age x location | 1 | 2.13 | 2.18 | 0.14 | 0.011 |
| gender x location | 1 | 1.24 | 1.27 | 0.26 | 0.006 |
| age x gender x location | 1 | 0.69 | 0.70 | 0.40 | 0.004 |
| Intrinsic Motivation | | | | | |
| Age | 1 | 6.82 | 9.15 | 0.00* | 0.044 |
| Gender | 1 | 7.87 | 10.56 | 0.00* | 0.051 |
| Location | 1 | 0.15 | 0.20 | 0.66 | 0.001 |
| age x gender | 1 | 0.96 | 1.29 | 0.26 | 0.007 |
| age x location | 1 | 0.04 | 0.05 | 0.92 | 0.000 |
| gender x location | 1 | 0.13 | 0.17 | 0.68 | 0.001 |
| age x gender x location | 1 | 0.02 | 0.03 | 0.88 | 0.000 |
| Extrinsic Motivation | | | | | |
| Age | 1 | 5.90 | 6.96 | 0.01* | 0.034 |
| Gender | 1 | 9.77 | 11.52 | 0.00* | 0.055 |
| Location | 1 | 0.85 | 1.01 | 0.32 | 0.005 |
| age x gender | 1 | 0.74 | 0.87 | 0.35 | 0.004 |
| age x location | 1 | 0.05 | 0.06 | 0.80 | 0.000 |
| gender x location | 1 | 0.20 | 0.23 | 0.63 | 0.001 |
| age x gender x location | 1 | 0.00 | 0.11 | 0.74 | 0.001 |
| Amotivation | | | | | |
| Age | 1 | 0.18 | 0.12 | 0.73 | 0.001 |
| Gender | 1 | 0.49 | 0.00 | 0.56 | 0.002 |
| Location | 1 | 0.14 | 0.10 | 0.76 | 0.000 |
| age x gender | 1 | 0.31 | 0.21 | 0.65 | 0.001 |
| age x location | 1 | 0.40 | 0.27 | 0.61 | 0.001 |
| gender x location | 1 | 3.21 | 2.16 | 0.14 | 0.011 |
| age x gender x location | 1 | 0.65 | 0.44 | 0.51 | 0.002 |

Analysis of variance for expectancy belief, subjective task values, intrinsic motivation, extrinsic motivation and amotivation as a function of age groups, gender and locality

(F(1,197) = 1.01, p > 0.05). There was no significant interaction between age x gender (F(1, 197) = 0.87, p > 0.05, partial $\eta 2 = 0.004$), age x location (F(1, 197) = 0.06, p > 0.05, partial $\eta 2 = 0.001$), and gender x locality (F(1, 197) = 0.23, p > 0.05, partial $\eta 2 = 0.001$). There was no interaction effect for age x gender x locality (F(1, 197) = 0.11, p > 0.05, partial $\eta 2 = 0.001$).

Finally, the ANOVA analysis for amotivation revealed that there were no significant main effects for age group (F(1,197) = 0.12, p > 0.05), gender (F(1,197) = 0.00, p > 0.05), and locality (F(1,197) = 0.10, p > 0.05). There was no significant interaction between age x gender (F(1, 197) = 0.21, p > 0.05, partial $\eta 2 = 0.001$), age x location (F(1, 197) = 0.27, p > 0.05, partial $\eta 2 = 0.001$), gender x locality (F(1, 197) = 2.16, p > 0.05, partial $\eta 2 = 0.011$). There was also no age x gender x locality interaction effect (F(1, 197) = 0.44, p > 0.05, partial $\eta 2 = 0.002$).

The Relationship Between Expectancy-Beliefs, Subjective Task Values, Intrinsic Motivation, Extrinsic Motivation and Amotivation

Table 4 shows the relationship between expectancy-beliefs, task values, intrinsic motivation, extrinsic motivation and amotivation. The score of expectancy values and subjective task values were highly correlated (r = 0.78). Expectancy values and intrinsic motivation were shown to be moderately correlated at r = 0.58. Subjective Task values were moderately correlated with intrinsic motivation (r = 0.65), and extrinsic motivation (r = 0.54). Intrinsic motivation was highly correlated with extrinsic motivation at 0.83 but weakly correlated with amotivation (r = 0.20). Amotivation was lowly correlated with all other components.

DISCUSSION

In line with the objective of the study, the results showed that male athletes had higher beliefs than female athletes. This finding was consistent with previous studies, which found that males showed higher competence beliefs than females (Gao & Xiang, 2008; Wigfield et al., 1997; Yli-Piipari et al., 2013). This could be due to the occurrence of gender-role stereotyping due to need to be feel socially accepted by the societies. These socially constructed gender-role stereotyping could pressure the boys and girls to behave in ways in order to satisfy society's expectations (Yli-Piipari et al., 2013). The male athletes are more likely to enjoy physical activities which deem to be challenging as sports have been

Table 4

| | Expectancy Beliefs | Subjective Task Values | Intrinsic Motivation | Extrinsic Motivation | Amotivation |
|---------------------------|-----------------------|---------------------------|-------------------------|-------------------------|-------------|
| Expectancy Values | - | 0.78 | 0.58 | 0.48 | 0.04 |
| Subjective Task Values | - | - | 0.65 | 0.54 | 0.04 |
| Intrinsic Motivation | - | - | - | 0.83 | 0.14 |
| Extrinsic Motivation | - | - | - | - | 0.20 |
| Amotivation | - | - | - | - | - |

Correlation between expectancy values, subjective task values, and three types of motivation

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perceived as masculine-typed tasks by societies. When the athletes feel that the activity is appropriate based on their gender role, they would feel more competent and maintain their effort, even under adverse conditions over time (Chalabaev et al., 2013). Stereotyping could decrease the female's performance and increase male's performance which could lead female towards negative health consequences by not exercising due to gender inequalities in health and physical activities in the long run.

However, certain findings from this study conflicted with previous studies. For example, previous studies found that vounger athletes have lower beliefs and task values than older athletes whose values tend to decrease across middle school years (Jacobs & Eccles, 2000; Xiang et al., 2006). However, our results supported the findings of Yli-Piipari et al. (2013), which showed that students' task values were stable across time. It could be that sports and physical education were taught by specialised physical education teachers that support athletes' needs in sports and physical education better than the untrained PE teachers. The trained PE teachers are able to adopt relevant strategies and pedagogical approaches that can motivate and enhance the adolescent athletes' learning and value in sports and PE. Moreover, the mastery motivational climate created by the coaches could have resulted in the older athletes valuing sports for interest (intrinsic), attainment and utility (extrinsic) reasons more than younger athletes. The findings also revealed that the male athletes had higher intrinsic and extrinsic motivation than female athletes. The male athletes internalized sports involvement as interesting, satisfying and enjoying. In addition, they are able to develop and improve their competency in their skills which lead to a sense of accomplishment improvement.

The enjoyment that male athletes experience in sports are more likely to continue in their engagement in sports due to their higher perceived competence. In addition, all stakeholders in sports such as coaches, PE educators and trainers need to strategize programmes that covers a broad variety of activities based on their level of abilities and competencies in order to increase the level of intrinsic motivation among the female athletes. As male athletes were also extrinsically motivated which is line with previous studies (Gillet et al., 2012; Monazami et al., 2012). The findings implied that external forces motivate the male athletes in the forms of recognition, approvals, rewards attractiveness and goods in sports. Therefore, it is necessary to always challenge these athletes to boost up their self-esteem and confidence in training to excel in their performance. Studies had shown the importance of an athlete being intrinsically and extrinsically motivated whereby the athlete would strive to be better and win competitively (McHale et al., 2005). In line with our current studies, Gillet at al. (2012) reported that intrinsic and extrinsic motivation were higher among older athletes as compared to the younger athletes. On the contrary, physical education participation

was on the decline as students progressed through 5th to 9th grades. This could be due to lack of emphasis, time allocation and priority given to sports in secondary schools, which tends to focus more on academic and examination excellence.

A task-supporting motivational climate that is oriented towards intrinsic and extrinsic factors has resulted in athletes who are older developing intrinsically and extrinsically in performing their activities throughout the year or season. This is in line with Yli-Piipari et al. (2013) study that revealed high motivation profiles were characterised by highly intrinsically and extrinsically students in their involvement in physical education. The satisfaction, personal accomplishment and interest that were attained through sports has resulted in the older athletes engaging more in it. On the contrast, external factors in terms of gaining recognition, results, rewards, pressure from peer and significant others such as friends, coaches, teachers and parents could have pressured the athletes to participate in sports. The transition from lower to upper secondary school does not result in changes in athletes' motivation as compared to previous studies, which show a developmental shift from intrinsic to extrinsic as they progress from primary to secondary school (Chin et al., 2012). It seems that the older athletes have learnt to adapt to the competitiveness and demands of the sports that have become more impersonal, formal, evaluative and controlling. However, the requirement for successful outcomes has created constant pressures regardless of age to train harder and longer from intense training to yearround competition. The non-self-determined form of motivation among the older athletes have resulted in negative outcomes in the form of lesser effort, enjoyment, satisfaction and boredom which could be due to lack of perceived autonomy support from significant others.

From the locality perspective, the finding does not support the previous study whereby urban male athletes had higher beliefs than rural male athletes, and rural athletes had higher task values than urban athletes (Chin et al., 2009). Chin et al. (2012) found urban athletes to be more intrinsically motivated than rural athletes. The nonsignificant differences in beliefs, values and types of motivation could be due to the role of significant others that provide a source of positive influence in these adolescent athletes. Despite the challenges, the ongoing commitment and involvement of significant others such as PE teachers, principals, coaches, parents and communities by providing adequate resources, opportunities, chances and guiding effort are able to sustain the athletes' level of beliefs and values in receiving quality sports coaching. This inferred that athletes are indifferent and similar within the variables of these two theories. Therefore, one's must be able to persist, tolerate and endure the hardships and sacrifices needed to survive to perform within the ever-changing environment in competitive sports.
The positive relationship between belief, task values, intrinsic motivation and extrinsic motivation supports the findings of previous studies, which revealed similar results (Chin et al., 2009; Van Heerden, 2014; Xiang et al., 2004). This implies that athletes who have higher beliefs in sports would be more intrinsically motivated as they value it as more exciting and extrinsically motivated as it is reflected towards the extrinsic values of utility and attainment. Therefore, these findings have shown that autonomous motivation correlated positively with beliefs and task values in cultivating adolescent athletes' long-term involvement in sports. The limitation of the study is that the participants are from just one state i.e., Sarawak therefore our conclusion cannot be generalised to the entire country. The future direction may include the comparison of team-based or individual based sports and the level of participation among athletes and non-athletes.

CONCLUSIONS

The study is able to contribute to the field of knowledge on gender, age group and locality on adolescents' beliefs, values and levels of autonomy in sports. For long term, it is imperative for adolescent athletes to be intrinsically motivated in order to sustain their level of performance and fitness. Furthermore, the higher authorities across sectors would need to be committed and accountable in delivering and implementing their policies and efforts to meet the athletes' physical and psychological needs to that enable the adolescent athletes to enjoy and capitalise the benefits of sports in the long run. Additionally, Malaysian athletes' motivation could be better understood by integrating Eccles et al. (1993) expectancyvalue model of achievement choice and self-determination theory.

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Skeletal Muscle Response to High-Intensity Interval Training (HIIT) in Older Adult Wistar Rats

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ABSTRACT

High-intensity exercise (HI), is known potentially to reduce cardiometabolic risk. However, HI is a constraint to older adults. The burdens of HI in older age can be achieved by high- intensity interval training (HIIT) which is considered to be useful. Although HIIT is considered as beneficial, its safety and feasibility in older adults should be carefully assessed. We studied the skeletal muscle response to HIIT in older adult rats. Fifteen male Wistar rats (12 months) were divided into 3 groups: HIIT group; control 1 (C1, 12 months);

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ISSN: 0128-7702 e-ISSN: 2231-8534 control 2 (C2, 14 months as sedentary control group. Parameters use are blood lactate; skeletal muscle's Troponin-T (TnT) and PGC-1 α . Treatment consisted of 4 minutes of high intensity active running on a treadmill with 1 minute interval; 4X of repetition for 8 weeks. After treatment rats were sacrificed, blood and gastrocnemius muscles were collected. Results showed that blood lactate in HIIT was insignificantly higher compared to C2 and was significantly higher in C2 compared to C1 (p=0.032). PGC-1 α in HIIT was significantly higher

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compared to C2 (p=0.024) and significantly lower in C2 compare to C1 (p=0.022). TnT of HIIT was significantly higher compared to C2 (p=0.002). Our results indicated that response of skeletal muscle tissue to HIIT for 8 weeks provided benefited and was feasible for older adults.

Keywords: High-intensity interval training (HIIT), lactate, older adult rats, PGC-1α, skeletal muscle, troponin T.

INTRODUCTION

Aging is a natural process in the life of a person who has passed his productive age, which is accompanied by a decrease in body function thus reducing the productivity of elderly people (Hansakul, 2010). In aging, the decrease of body functional capacity occurs gradually and is irreversible to the extent of failure and even death. Decrease of body functional capacity occurs from molecules, cells, and tissues level even at organ level (Hansakul, 2010; Masoro & Austand, 2011). One of the most commonly impaired is the musculoskeletal system. The changes that occur in the musculoskeletal system include decreased muscle mass and size, reduced contractile ability, decreased α -motor neuron nerve fibers, decreased protein synthesis, neuromuscular junction changes and decreased Ca²⁺ insarcoplasmic reticulum (Narici & Maffuli, 2010; Setiati, 2013). Reduced muscle function due to decreased muscle mass and decreased muscle strength is known as sarcopenia. Sarcopenia ultimately leads to decrease

of physical activity, decreased mobility, slow walking, and low physical endurance capability (Saxon et al., 2015; Setiati, 2013).

In the elderly, the gradual decrease in skeletal muscle mass, strength and endurance is followed by ineffective response to tissue damage. Moreover agedependent muscle wasting is also known to associate with the mechanism of uncoupling between excitation and muscle contraction, impaired muscle protein synthesis and impaired in metabolic pathways. Proteomic analysis showed that there are some changes in senescent muscle fibers including the transformation of fast-to-slow types of muscle fibers, increase in the amount and phosphorylation levels of slow myosin light chain, and a switch to slower isoforms of contractile protein including actin, myosin, tropomyosin and troponin complex (Ohlendieck, 2011). Troponin is one of the filament regulatory protein that is crucial for contraction of skeletal muscle and regulated by calcium intracellular level.

The decrease in muscle mass that causes the change of muscle contraction strength is thought to be related to changes in energy metabolism within the skeletal muscle. In this condition, the decrease in mitochondrial biogenesis contributes to the decline in skeletal muscle function (Marzetti et al., 2013). It has been reported that moderate-intensity exercise can lead to increased mitochondrial biogenesis and play an important role in preventing aging (Kang & Ji, 2013).

High-intensity interval training (HIIT) is a type of exercise with high intensity in a

short time, accompanied by recovery time or interval. HIIT duration varies from 60 seconds to 20 minutes with a heart rate of 90-100% maximum heart rate. Research on HIIT is still very limited. Shorter duration of HIIT is expected to be a great advantage for busy individuals with less time for physical exercise. However, high-intensity exercise of HIIT causes the availability of oxygen in the muscle tissue is reduced so that the generated energy comes from the anaerobic process. Anaerobic energy systems will produce lactic acid, which can cause muscle fatigue if lactic acid accumulates (Perry et al., 2008; Adeva-Andany et al., 2014). The presence of intervals after highintensity exercise results in a combination of anaerobic and aerobic energy metabolism (MacLaren & Morton, 2012; Siahkouhian et al., 2013). High-intensity exercise of HIIT causing HIIT may allegedly improve fitness conditions, increase glucose metabolism and fat burning (MacLaren & Morton, 2012; Perry et al., 2008).

From the existing studies, it is still not known exactly about the role of HIIT associated with changes in muscle contraction and energy metabolism. Therefore this study was conducted to see the effect of HIIT on skeletal muscle response in older adult of Wistar rats as the animal model.

METHODS

All experiments in this study were performed in accordance with the guidelines animal research from the National Institute of Health and were approved by the Ethical Committe Faculty of Medicine Universitas Indonesia (Ethical approval No.676/UN2. F1/ETIK/2016). This study was performed at The Integrated Laboratory of Medical Faculty Universitas Indonesia for ELISA measurements of Troponin T and PGC 1- α , while blood lactate measurement was conducted at Laboratory of Biochemistry and Molecular Biology of Medical Faculty Universitas Indonesia.

Animal

This study used fifteen 12 months old male Wistar rats which were randomly divided into control 1 group (C1) and 14 months age as a control 2 (C2). Both control groups were not given HIIT treatment and 12 months age which were given HIIT for 8 weeks (14 months at the end of the treatment), and defined as HIIT group.

Prior to the treatment, the rats were acclimatized to be familiar with the research environment or days. The rats were fed with standard chow and had free access to drinking water ad libitum.

The rats were housed in cages that were kept clean and was set to 12 hours of light and dark cycle. The ambient temperature was maintained at 23°C.

In this research, the use of different age group was to see: the process of aging in the old adult age (12 until 14 months) sedentary rats, and the process of aging with intervention of HIIT. C1 was used as baseline data for the aged 12 months rats which was the same as 18-20 years of human age. C2 was used as a control group to compare with the treatment group that was 12 months age with 8 weeks of exercise to become 14 months age. HIIT group was used as a Treatment group from 12 months age until 14 months age. As we know, 14 months age for a rat is the same as 30-35 years old of human age. (Andreollo et al., 2012; Sengupta, 2011 & 2013).

HIIT Treatment

This experimental work used an animal treadmill to perform exercise training. The treadmill consisted of 6 single lines and each rat could run individually in a single line. The protocol was examined from previous study (Arabmomeni et al., 2015; Hafstad et al., 2011; Manchado et al., 2005). Prior to the treatment, the rats were acclimatized using the treadmill for 5 days and the speed received was 15m/ min for 10 minutes/day. HIIT was performed 5 days/week for 8 weeks. It consisted of 4 repetitions of 4 min running at high intensity interspersed by 1 min of active rest. At the first week, the rats ran on a treadmill with a speed of 16 m/min and increased gradually up to 25 m/min at week 8. In each training session, rats performed 5 min warming- up and 5 min cooling-down.

Data Collection

At the end of the 8th week exercise (after treatment), blood was taken from the tail vein for lactate measurements; then the rats were decapitated and gastrocnemius muscle was taken for measurement PGC- 1α and troponin-T concentration in muscle. Skeletal muscle homogenate was prepared by weighing up skeletal muscle as much as 100mg and homogenized in 1 mL PBS

solution. The homogenates were performed for 2 times storage cycle for 24 hours in -20°C, to disrupt the cell wall. The tissue homogenates were then centrifuged at 5000 x g for 5 minutes, and the supernatant was taken. Aliquots of supernatant were and stored at -20°C before measurement. The remaining tissue samples were then stored at -80°C for further usage. Total protein concentration of the skeletal muscle extracts was measured by the Bradford method (Cusabio, 2016; Elabscience, 2016). Concentration of rat troponin T (TnT) and PGC- α were reported as mg/g total protein.

Blood Lactate Concentration

Measurement of blood lactate concentration was done according to the procedure of commercially available kit (Lactate kit, LC 2389 Randox) based on spectrophotometric colorimetric. The blood was taken from the tail vein as much as 1mL and centrifuged at 1000xg for 10 minutes and the plasma were taken as sample. The absorbance results were read at wavelength of 550 nm. The standard curve was made from the standard solution according to the kit's protocol. Lactate concentration was calculated by comparing absorbance of lactate in the sample with a known concentration from the standard curve.

Troponin T Quatification in Skeletal Muscle

Troponin T (Tn-T) concentration was measured with commercially available enzyme immunoassay Rat Tn-T Elisa kit (Rat TnT, ELISA E-EL-R0054, Elabscience) based on Sandwich ELISA method. The homogenate solution was used as much as 100µL for each well. The micro ELISA plate had been pre-coated with an antibody specific to Rat TnT. Standards or samples were added to the appropriate micro ELISA plate wells and combined with the specific antibody. Then a biotinylated detection antibody specific for Rat TnT and Avidin-Horseradish Peroxidase (HRP) conjugate was added to each micro plate well successively and then incubated. Only those wells that contained Rat TnT, biotinylated detection antibody and Avidin-HRP conjugate would appear blue in color. Concentration of Troponin T in muscle was calculated by comparing the absorbance of the sample with the absorbance of Troponin T standard curve at 450 nm wavelength.

PGC-1α Quantification in Skeletal Muscle

PGC-1 α concentration was measured with commercially available enzyme immunoassay Rat peroxisomeproliferatoractivated receptor gamma co-activator 1-alpha (PGC-1a ELISA CSB-ELO18425RA, CusaBio), based on sandwich ELISA technique. Antibody that was specific for PGC-1 α had been pre-coated onto a microplate. Standards and samples were pipetted into the wells (@ 100 μ L) and any PGC-1 α present was bound by the immobilized antibody. After removing any unbound substances, a biotinconjugated antibody specific for PGC-1a was added to the wells. After washing, avid in conjugated Horseradish Peroxidase

(HRP) was added to the wells. The PGC-1 α concentration was calculated from the absorbance of PGC-1 α in sample with the absorbance of known concentration of the standardPGC-1 α at 450 nm wavelength.

Statistical Analyses

Data obtained from each parameter is expressed in mean \pm SD and analyzed using SPSS version 19. Statistical analysis was performed using student t-test. Statistical differences for each parameter between groups were considered as significant if p< 0.05.

RESULTS

Blood Lactate Concentration

Plasma concentration of lactate was measured right after the last exercise at the end of week 8. Our results demonstrated that control group 2 (C2) had significantly higher in plasma lactate (4.12 ± 1.20 mmol/l) compared to control group 1 (C1) (2.50 ± 0.71 , p = 0.032 mmol/l). The HIIT treatment in HIIT group showed to have tendency of lower plasma lactate concentration compared to control without exercise in same age (C2), although it was insignificant (p = 0.381) (Figure 1).

Troponin T Content in Muscle

Our results had demonstrated that there was tendency to decrease the Troponin T Concentration $(1.53 \pm 1.57 \text{pg/mg})$ from the older rats to younger age or control 1 group $(2.41\pm1.63 \text{pg/mg}, \text{p}=0.415)$. HIIT exercise group had significantly higher troponin T



Figure 1. Lactate concentration in the blood. C1 is 12 months old without exercise, C2 is 14 months old without exercise and HIIT is 14 months old rats with HIIT treadmill exercise (HIIT group). C2 group shown to have higher blood lactate compared to C1 group (p = 0.032). Data are expressed in mean \pm SD, analyzed with student t test, significantly difference *p<0.05



Figure 2. Troponin T concentration in skeletal muscle. HIIT exercise in HIIT group demonstrated higher concentration of troponin T in skeletal muscle compared to without exercise (C2 group) (p = 0.002). Data are expressed in mean \pm SD, analyzed with student t test, significantly difference *p<0.05

concentration $(5.05\pm0.74 \text{ pg/mg})$ compared to C2 group $(1.53\pm1.57 \text{ pg/mg}, \text{p} = 0.002)$ (Figure 2).

PGC-1a Content in Muscle Tissue

PGC-1α in muscle tissue could represent the biogenesis of mitochondria and also play important rolein muscle metabolism during exercise. Our results showed that there was significant lower PGC-1 α concentration in skeletal muscle (148.260±102.41 pg/mg) of the older group compared to younger age or C1 group (386.33±156.43 pg/ mg, p = 0.022). While exercise treatment with HIIT (HIIT group) showed higher PGC-1 α concentration in skeletal muscle $(304.540\pm0.74 \text{ pg/mg})$ compared to the same age without exercise or C2 group (148.260±102.41 pg/mg, p=0.024). (Figure 3.)

DISCUSSIONS

Our results showed that there was an insignificant difference between blood lactate levels in HIIT group and C2 group but there was a significant difference of blood lactate level between both control groups, i.e. C2 vs C1 groups. Blood lactate was identified as an indicator of an increase on glycolytic metabolism during exercise (Arabmomeni et al., 2015). The normal level of blood lactate is 0.5 - 2.2 mmol/L. This parameter is considered as a good indicator of the high-intensity exercise capacity. The peak of blood lactate concentration occurs approximately 5 min after the cessation of intense exercise (Arabmomeni et al., 2015; Manchado et al., 2005). Brito

Vieira et al. (2014) defined that lactate threshold within the range of submaximal exercise intensities, normally between 50 and 80% of maximum load and blood lactate concentration approximately up to 4 mmol/L. This lactate threshold is important in examining high-intensity exercise with the interval (Arabmomeni et al., 2015). Lactate in the age of old adult rats (HIIT group), HIIT does not cause errors or disruption (performance does not go down) and does not cause injury.

Aging causes modification of body compositions that alter muscle structure and reduce the ability to perform the exercise requiring strength and power. Muscle fiber composition changes with a reduction in the number of type I (slow twitch) and type II (fast twitch) fibres with selective atrophy of type II fibres (Arabmomeni et al., 2015). This is one of the skeletal muscle response to aging. Blood lactate



Figure 3. PGC-1 α concentration in skeletal muscle. C2 group showed significantly lower in PGC-1 α concentration in skeletal muscle compared to younger age or control 1 group (# p = 0.022). HIIT exercise in HIIT group demonstrate higher the concentration of PGC-1 α in skeletal muscle compared to without exercise or C2 group (*p = 0.024). Data are expressed in mean \pm SD, analyzed with student t test, significantly difference *p<0.05 (p=0.024). #p<0.05 (p=0.022)

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level in older rats decreased during HIIT treatment compared to the same age (C2). Blood lactate level in older rat without HIIT treatment (14 months) was higher compared to the younger age (12 months). As we know, aging is associated with a minimum efficiency of glycolytic enzymes, lactate dehydrogenase and hexokinase enzymes. It is also stated that citrate and citrate synthase are reduced in muscle (Arabmomeni et al., 2015). Arabmomeni et al. (2015) stated that increased of muscle lactate would decrease muscle pH during high-intensity exercise. Following release of lactate from skeletal muscle, lactate, and hydrogen ions from red blood cells into the plasma are transported to the liver. In the liver, lactate underwent gluconeogenesis process to form glucose. It looks like exercise with enough intensity leads to lowering the blood lactate level because the interval has the greater effect on the lactate clearance.

Troponin T (TnT), as we know, as a function of contraction muscle and the sarcomeric Ca²⁺ is the regulator of striated (skeletal and cardiac) muscle contraction.

On binding Ca^{2t} TnT transmits information via structural changes throughout the actin- tropomyosin filaments, activating myosin ATPase activity and muscle contraction (Gomes et al., 2002). Our result showed that TnT protein control in the muscle of older rat with HIIT treatment was higher compared to the same age without HIIT treatment. That means that HIIT treatment alters the fibre proteome following the stimulation of AMP-activated protein kinase (AMPK) and elevation of sarcoplasmic Ca^{2t} levels during muscle contraction (Ohlendieck, 2011). In aging, there is a loss of skeletal muscle mass accompanied by the considerable decline in contractile strength (Faulkner et al., 2007). HIIT treatment proved to increase the protein content of TnT in the muscle of the old adult group. Norheim study found that there was secretion of signalling protein from human skeletal muscle cell in response to strength training (Ohlendieck, 2011).

Aging has been associated with the decline in mitochondria content and function (Menshikova et al., 2006). It is known that PGC-1 α is a transcriptional coactivator that controls expressions of genes related to energy metabolism. PGC-1a control biogenesis and function of mitochondria (Jung & Kim, 2014). Our results found that PGC-1a in muscle tissue was increased in older rats with HIIT treatment compared to the same age without HIIT treatment (C2 group). Peroxisome-proliferator-activated receptor y coactivator (PGC)-1a, is regarded as the 'master regulator' of mitochondrial biogenesis in muscle. Evidence suggests that exercise intensity is the key factor influencing PGC-1a activation in human skeletal muscle (Gibala, et al., 2012). In skeletal muscle, PGC-1a expression is activated during muscle contraction through Ca²⁺/calmodulin dependent protein kinase IV (CamKIV) and calcineurin A, which are activated through calcium ion dynamics within the muscle in response to exercise. The increased calcium signaling during muscle contraction activities stimulates several important transcription factors such

as cAMP-response element binding protein (CREB), p38 mitogen-activated protein kinase (MAPK). Exercise will activate MAPK, increase ratio AMP: ATP and also Ca^{2t} flux, during muscle contraction (Kang & Ji, 2013). This study has limitations because in this research, soleus muscle was not used as slow twitch fiber to compare the measurements with fast twitch fiber, did not measure complete protein contractile like actin, myosin heavy chain, tropomyosin, Troponin I and Troponin C to see the difference between different age in control group and treatment group.

CONCLUSIONS

We conclude that HIIT is a powerful stimulus to muscle activity, maintaining the strength of skeletal muscle which is shown by increase Troponin T content in the muscle which is important in muscle contraction and increase PGC-1a that plays a vital role in the regulation of substrate metabolism and energy production. HIIT treatment for 8 weeks proved to be safe which was shown by the blood lactate concentration. This research uses HIIT by measuring muscle mass and strength, so we get the best HIIT formula to be applied in older adult so they can maintain healthy life. Further research is needed to determine the effect of HIIT on protein contractile level, and modifying HIIT training protocol especially when it is applied to humans especially among the elderly adults.

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