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SPORTS AND EXERCISE MEDICINE

Open Journal

| June 2017 | Volume 3 | Issue 2 |

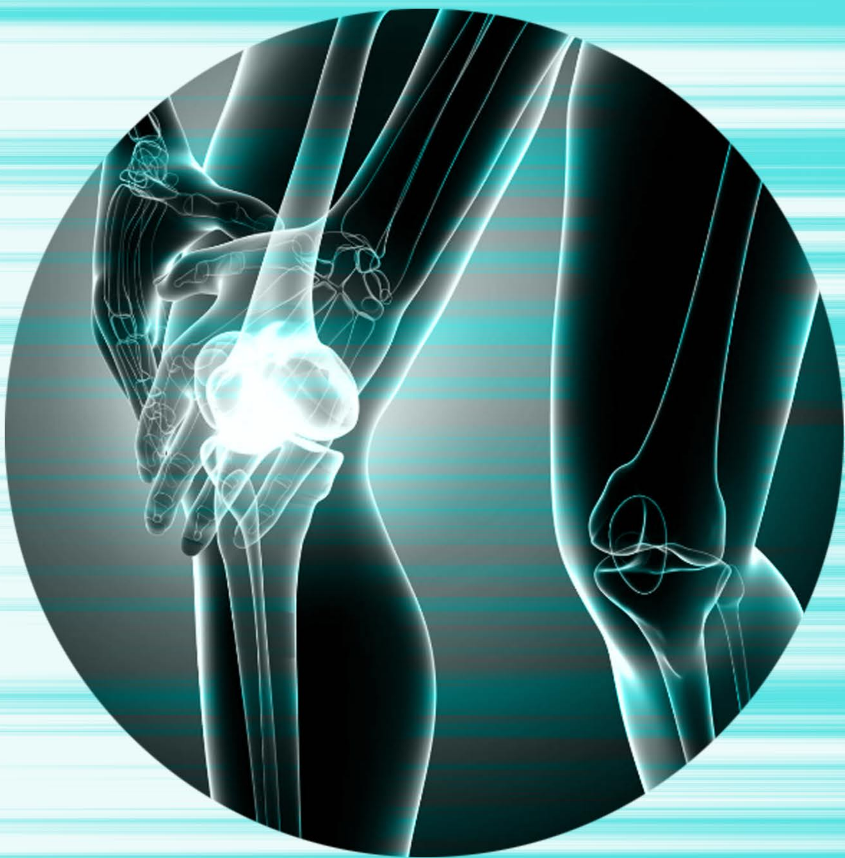

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TABLE OF CONTENTS

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Open Journal

http://dx.doi.org/10.17140/SEMOJ-3-145

Research

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Volume 3 : Issue 2
Article Ref. #: 1000SEMOJ3145

Article History
Received: March 15th, 2017
Accepted: April 7th, 2017
Published: April 24th, 2017

Citation
Mills C, Burnett R. An investigation into physical activity levels in primary school playgrounds. *Sport Exerc Med Open J*. 2017; 3(2): 30-39. doi: 10.17140/SEMOJ-3-145

An Investigation into Physical Activity Levels in Primary School Playgrounds

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ABSTRACT

Background: As children spend roughly 30 hours per week at school, the associated benefits of physical activity (PA) can be developed within physical education (PE) lessons, break times and after school activities. Therefore, the main aims of this investigation were to (i) investigate the differences between males and females PA levels across the tarmac area during lunch time, (ii) investigate the impact of staff/teacher supervision and (iii) to determine the effect of the weather on PA within the playground during lunch times and (iv) finally establish how pupils feel levels of PA could be increased during lunchtime.
Methods: A mixed methods approach was undertaken to explore children's PA levels and the effect of gender, adult supervision and weather during school lunchtimes using n=132 participants aged 5-12 years. Moderate-to-vigorous (MPVA) PA levels were measured using systematic scans in 3 playground areas during 3 separate lunchtimes using an adapted version of McKenzie's pro forma. Focus groups on n=16 pupils aged 7-11 years were conducted to help improve understanding of the effects of supervision and weather on PA, and how levels of PA can be increased.
Results: Paired sample t-tests results revealed that males were significantly more active in area one than area two (p=0.04) and females were significantly more active in area three than area one (p<0.01). Focus groups highlighted that supervisors made little impact upon PA, whilst hotter weather was reported to negatively affect PA levels, as children engaged in less active activities to avoid sweating.
Conclusions: Overall males were observed to have higher levels of PA during the study, supervisors were important for health and safety but rarely encouraged PA and finally, participants claimed that they were less active when it was hotter.

KEY WORDS: Physical activity; Primary schools; Children; Play; Playgrounds; Lunchtime; Gender; Adult supervision; Weather.

ABBREVIATIONS: MPVA: Moderate-to-vigorous; PA: Physical Activity; SO: Statistics on obesity; DHSCIC: Diet by health and social care information centre.

INTRODUCTION

A physically active (PA) lifestyle during childhood has been positively correlated to lifelong engagement and as such is acknowledged to support health benefits including maintenance of body weight, improved mental and social health including reduced levels of depression, anxiety and improved self-esteem.[1] Furthermore, PA promotion for children is seen as an influential factor in reducing the risk of developing cardiovascular disease, obesity, cancer, diabetes and osteoporosis.[2] However, there is mounting worry that children are not participating in enough PA, increasing their risks of not only sedentary behavior but inevitably being overweight or obese with associated health issues such as cardiovascular disease and diabetes.[3] Examination of statistics on obesity (SO), PA and diet by health and social care information centre (DHSCIC)[4] identified that there was a 7% decrease from 28% to 21% for boys and a 3% decrease from 19% to 16% for girls (aged 5-15 years) that meet PA recommendations of sixty minutes activity per day. Consequently, as children spend roughly thirty hours per week at school, this

ISSN 2379-6375
http://dx.doi.org/10.17140/SEMOJ-3-145

makes an ideal forum to develop and encourage PA and its associated benefits. Moreover, health and physically active behaviours can be shaped through physical education (PE) as part of the National Curriculum, lunchtime PA and extracurricular activities.[5] Although unstructured, non-curricular PA activity during playtimes, before or after school, can provide children with additional opportunities to achieve daily PA recommendations.[6]

Physical Activity within Primary Schools

Schools have been encouraged by current and recent governments to promote PA with many documents and initiatives supporting it as a means to combating health problems.[7] However, due to the irregularity and need to teach curricular content, PE alone cannot offer adequate activity to achieve daily PA guidelines and promote mental and physical health benefits.[8] School resources and curriculum demands limit the time available for PE. Hence children are less likely to engage in PA and in some instances recent reports have indicated a decline in the time assigned to PE and break time by as much as fifty minutes per week.[8] Research conducted by Dobbins et al[9] and Pate et al[10] suggested that school-based interventions could successfully contribute to children's daily PA and raise academic attainment. However, to be implemented effectively, strategies must be cost-effective, discreet and linked to pupils academic achievements to encourage interest and increase concentration.[11,12]

Playtime's Opportunity to Promote Physical Activity in Schools

In the United Kingdom break time is compulsory and can equate for up to a quarter of the school day.[13] Sufficient playtime (at least twenty minutes), should be a scheduled part of every school day and playgrounds should be designed to help children engage in MVPA.[14] Playtime may prove to be the greatest chance children have to be active, as playtime exceeds that in structured PE lessons.[15] Yet research shows that several children only use half of their school break time being active.[9] Other than the health benefits and contribution to PA levels, playtime allows children to socialize and have a break from the classroom.[16] Playtime supports constructive learning behaviours, problem solving and learning enthusiasm.[14] Allowing children to use their imagination, making up rules, forming their own activities, making decisions and developing friendships, showing how it is important for children's social and cognitive development.[17] Playtime is also becoming a victim of a societal drive for safety.[18] School policies are constructing behaviorally or environmentally with controlled school settings such as 'no ball games' or 'no contact games'. Therefore to promote PA, children need the opportunity to participate in their preferred activity, and the access to variable playground environments including open and quiet spaces.[9] An earlier study by Parrish et al[18] recognized environmental variables that increased children's PA including playground loose equipment, shaded and un-shaded areas, whilst teacher observation, and being female all reduced PA participation. Additional variables including gender differences, size of the playground, quantity of equipment, staff supervision and the weather, influence variances in children's PA during unstructured playtimes.[19,20]

Effect of Gender Differences in Children's Physical Activities

Multiple studies focusing on PA in a school environment have reported males engaged more in MVPA than females, with males viewing lunchtime as an opportunity to participate in active games whereas females view lunchtime as a chance to socialize with friends.[10] Males are accepted to take part in established ball and chasing games, whilst females are likely to enjoy jumping and verbal games such as skipping or clapping games.[21] Females' PA engagement has shown to increase on green open spaces where they can play without being pushed to the side by males' space with consuming games such as football.[22]

Effect of Playground Equipment in School Playgrounds

Previous studies by Huberty et al[22] and Ridgers et al[23] have reported positive benefits on introducing game equipment as a low cost method to increase PA. Verstraete et al[24] provided game equipment during playtime and reported a mean 13% increase (from 48% to 61%) MVPA engagement. The intervention was effective for both genders, however to encourage more activity greater quantities of equipment should be provided.[23] Playground equipment may not be adequate to increase PA alone schools also require effective teacher supervision.[25]

Effect of Staff Supervision during Physical Activity

Ridgers et al[23] highlighted that staff allowed children free choice over their activity choice during playtime and were not involved in implementation or organization of any activities. However, Parrish et al[8] reported that 42% of children believed that teacher interactions encouraged them to be more active whilst 50% of the teachers believed their presence had a negative effect, especially with the added pressure of complying to school rules.[19] Furthermore, the number of staff supervising a playground has not been linked with increases to PA during playtime according to Ridgers et al.[23] Improving staff knowledge and encouraging teachers to promote the use of equipment and all the available playground space may increase children's MVPA engagement.[26] However, playtime is seen as a voluntary opportunity for activity engagement that is free from adult control, hence supervisor implementation needs to be systematic to not affect children's free choice.[23]

Effect of the Weather during Physical Activity

Although, there are obvious seasonal variations with weather, rising temperature and decreasing levels of rainfall are shown to increase daily levels of PA especially in the summer months.[27,28] In a school environment children are often active outside, hence, inclement weather such as rain, snowfall and wind are seen as a barrier to being physically active.[30,31] Although playtime is shown to promote PA within school environments, the present

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-145

study aimed to explore children's PA levels during school lunchtimes through a combination of observations and focus groups.

Overall, the main aims of this investigation were to (i) investigate the differences between males and females PA levels across the tarmac area during lunch time, (ii) investigate the impact of staff/teacher supervision, (iii) determine the effect of the weather on PA within the playground during lunch times and finally (iv) establish how pupils feel levels of PA could be increased during lunchtime.

METHODS

Participants and Recruitment

A purposeful sample was selected from a primary school in Gloucestershire. The chosen primary school had n=132 registered pupils, (n=70 females and n=62 males) aged between five to twelve years old which made up the observation sample population. A purposeful sample of n=16 pupils was selected to participate in the four focus groups with two males and two females sampled from years three to six. To create small cooperating groups participants were sampled by gender and age. Ethical approval was granted from the University of Gloucestershire's Research Ethics Committee and owing to the target group being under 18 years of age, parental consent was obtained, in addition to consent from the head teacher of the primary school. All participants were aware of their involvement and were given brief details on the nature of the study and anonymised by number coding and confidentiality ensured with a password protected personal computer.

PROCEDURE

Following a sequential explanatory approach quantitative (observation) data was collected before qualitative (focus group) data. A detailed map of the whole school playground was obtained by the school groundskeeper and used to identify three target areas and playground equipment within the tarmac section of the playground (Figure 1) (Area 1 consisted of wooden aeroplane themed climbing equipment set in soft bouncy tarmac; Area 2 consisted of seating area with wooden benches with partial shelter and Area 3 consisted of cobbled stone area, trim trial and amphitheater with partial shelter).

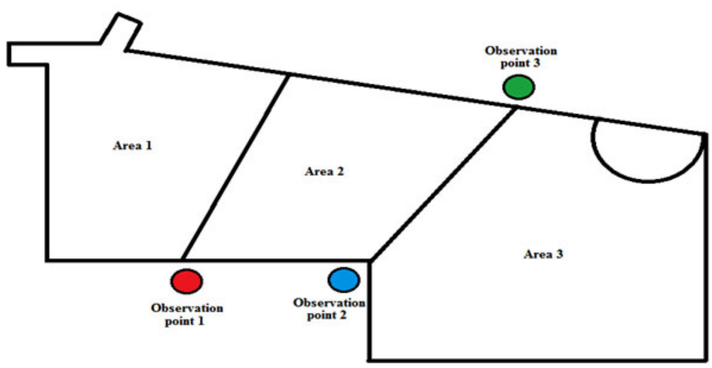
Quantitative observation data was assessed using an adapted version of McKenzie's System for Observing Play and Leisure Activity in Youth (SOPLAY).[30] A pilot study was conducted and the proforma was adapted to include tick boxes, activity codes (i.e., jumping games, ball games, chasing games, throwing games, etc.) and different sheets for each area. Observations were conducted on three separate occasions for a period of ten minutes for each of the three areas. Observations did not start until fifteen minutes into the school's lunch period to allow children to relax into their activities. Systematic scans from left to right were conducted to identify and record the frequency of females and males engaging in sedentary, light or vigorous activities, supervision, equipment usage and the most prominent activity in each of the tarmac areas.

Qualitative data was collected after playtime *via* focus groups that allowed participants to express their own experiences, opinions and attitudes towards their PA participation and the use of playground equipment. Main themes relating to the aims of the research including playground activities, markings, supervision, weather, gender, design and equipment were identified (Figure 2). Themes where then used to create an interview guide, where each theme was divided into sub-themes and questions. Focus group interviews lasted ~15 minutes.

Data Analysis

Observation data included analysis of the mean values of females and males (MVPA) using paired sample t-tests. Focus group analysis involved transcription of the recorded interviews to gain scripted proof of the discussion. Additional breakdown and assessment of the data was through the use of a direct content analysis approach. Coding began in relation to pre-deter-

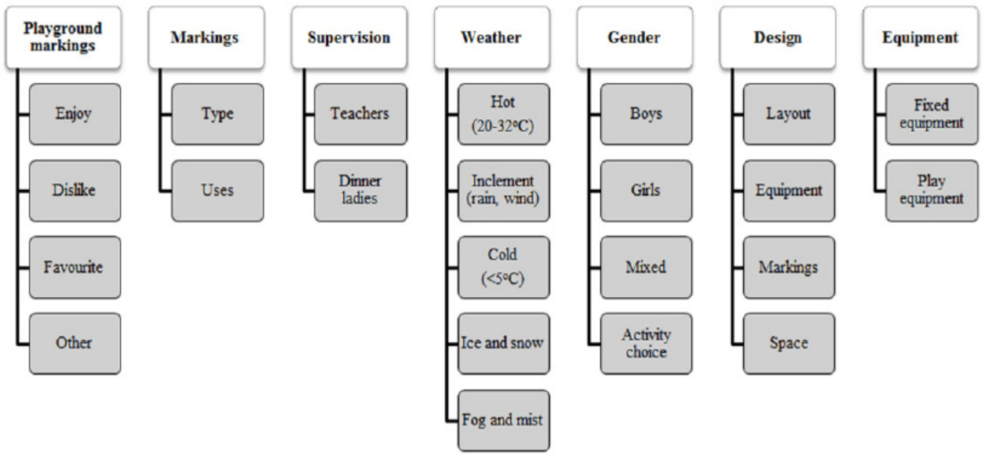
Figure 1. Observation Points Across the Playground Tarmac Area.



ISSN 2379-6375

http://dx.doi.org/10.17140/SEMOJ-3-145

Figure 2. Focus Group Questioning Themes in Relation to Physical Activity in Primary School Playgrounds.



mined themes (Figure 2) and data that was not coded based on these themes, was analyzed later to see if they represent a new category. Once the transcript was produced, clear topics that were relevant to the research aims were highlighted using the scissor and sort technique.

RESULTS

Quantitative (Observation)

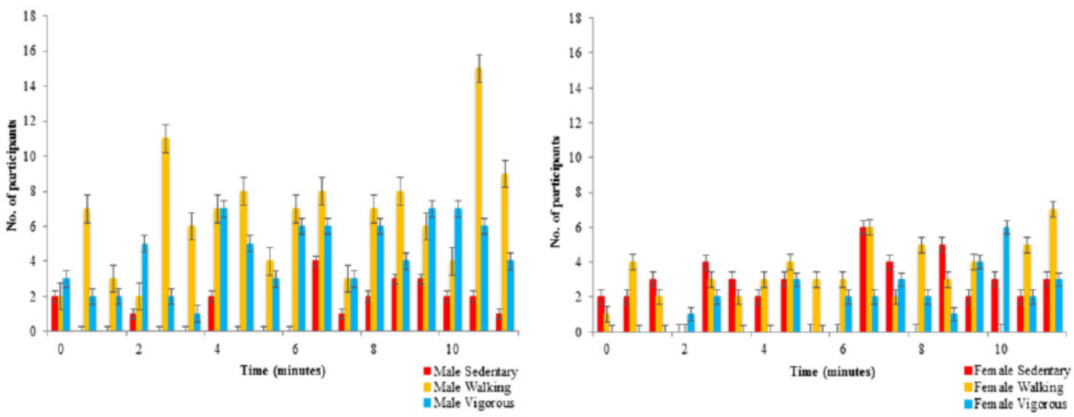
Results indicated that there was a significant difference ($p<0.01$) in sedentary activity between males (M=3.11±2.48) and females (F=1.85±2.10) with females having more sedentary behaviour than males. Additionally, monitoring levels of vigorous activity showed a significant difference ($p<0.01$) between males (M=3.76±2.22) and females (F=1.98±1.84) with males being more vigorously active. However, there was no significant difference in levels of moderate activity ($p=0.59$) between males (M=5.04±3.50) and females (F=5.41±4.24), suggesting minimal difference in the number of males and females that were moderately active. Similar results were observed in previous studies including Morgan et al[32] and Parrish et al[8] where boys engaged in more moderate-to-vigorous PA than girls.

Playtime Physical Activity Levels Across the Tarmac Area-Area 1

Results indicated that there was a significant difference ($p=0.01$) between male sedentary (M=1.28±1.27) and female sedentary (F=2.44±1.72). These results suggest that female participants in area one were more sedentary than male participants as illustrated in Figure 3.

Additionally, there was also a significant difference ($p<0.01$) between male walk (M=6.50±3.29) and female walk (F=3.17±1.89), suggesting that male participants were more moderately active (walking) than females. Finally, there was a significant difference ($p<0.01$) between male vigorous

Figure 3: The Number of Male and Female Participants and their level of Physical Activity Observed in Area One, during each Observation over a Ten Minute Period.



ISSN 2379-6375

http://dx.doi.org/10.17140/SEMOJ-3-145

(M=4.39±1.98) and female vigorous (F=1.72±1.67), suggesting that male participants were more vigorously active than female participants in area one.

Playtime Physical Activity Levels Across the Tarmac Area-Area 2

There was not a significant difference (p=0.06) between male sedentary (M=1.17±1.04) and female sedentary (M=1.94±1.31) PA. This can be observed in Figure 4, where the total number of female participants observed as sedentary was slighter higher than males (n=35 and n=21), showing a relationship but not a significant difference.

Moreover, there was not a significant difference (p=0.20) between male walk (M=4.22±3.32) and female walk (F=3.17±2.50), suggesting that there is not a clear difference in the number of participant's that were engaged in moderate activity. However, there was a significant difference (p<0.001) between male vigorous (M=3.78±2.21) and female vigorous (M=1.94±2.04), which suggests that male participants were more vigorously active in area two than female participants.

Playtime Physical Activity Levels Across the Tarmac Area-Area 3

Firstly, there was a significant difference (p=0.05) between for male sedentary (M=3.11±2.91) and female sedentary (M=4.94±3.00), suggesting that female participants are more sedentary than male participants. Secondly, there was a significant difference (p<0.01) between male walk (M=6.50±3.57) and female walk (F=9.89±3.57), which is suggestive of male participants engaging in less moderate (walking) activity than female participants. Figure 5 exhibits this as n=117 males were observed as walking compared to n=178 females. However, there was not a significant difference (p=0.16) between male (M=3.11±2.40) and female (F=2.28±1.84) vigorous activity scores, suggesting that there was not a clear difference in male and female participants engaging in vigorous activity.

In summary, area one indicated there was a significant difference (p<0.01) between male (M=4.06±3.15) and female (F=2.44±1.83) overall activity levels, with males being more active than females. However, in area two there was not a significant difference (p=0.07) between males (M=3.06±2.70) and fe-

Figure 4. The Number of Male and Female Participants and their Level of Physical Activity Observed in Area Two, during each Observation Over a Ten Minute Period.

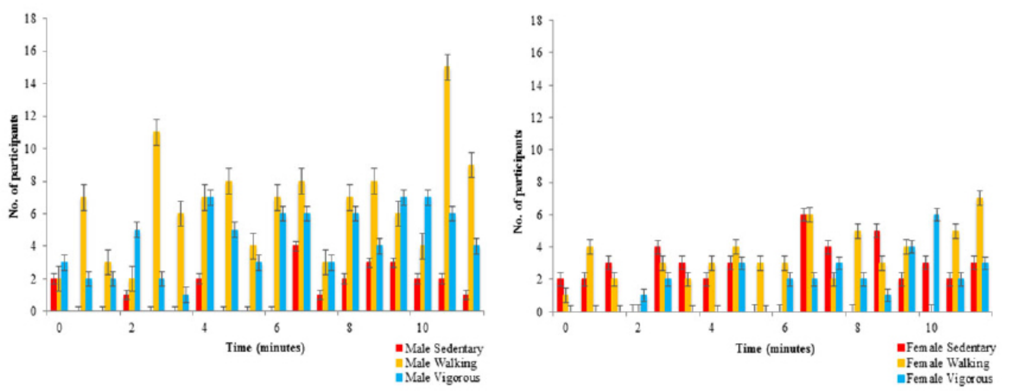
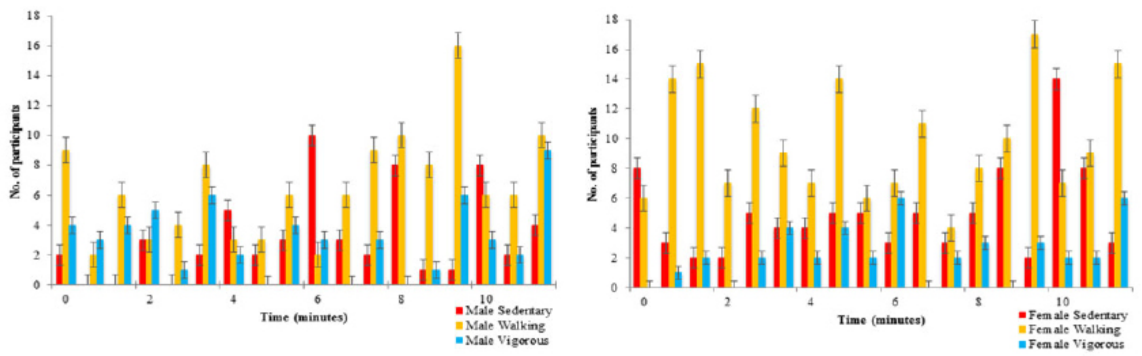


Figure 5. The Number of Male and Female Participants and their Level of Physical Activity Observed in Area Three, during each Observation Over a Ten Minute Period.



ISSN 2379-6375

http://dx.doi.org/10.17140/SEMOJ-3-145

males (F=2.35±2.06) overall activity levels, although there may have been a relationship, with males being slightly more active. Finally, in area three there was a significant difference (P=0.01) between males (M=4.24±3.35) and females (F=5.70±4.33) overall activity levels, suggesting that males were more active than females in this area. Additionally inspecting Figures 3, 4 and 5, participant numbers were higher in area three compared to area one suggesting that a large number of pupils prefer being active in area three. This may be due to its variety of open spaces, landscape changes and equipment availability.[22]

Qualitative (Focus Group)

Gender differences: Males were identified to have engaged in more vigorous activity and females more sedentary activity during lunchtime. These results support previous findings where males engaged in more activity than females[10,31] and contradict those of[32,33] student views supported the observation results as they identified that boys appeared to be more active than girls:

"*Boys run around more"* (participant 11)

"Boys more than girls" (participant 15)

"We exercise more than girls" (participant 16)

"The girls are lazy they don't run or exercise" (participant 13)

Differences between males and females in the level of PA engagement across each area were observed. Males were seen to be more significantly active in area one than in area two (p= 0.04) however, there was no significant difference between female activity between areas one and two (p=0.77). Furthermore, both males and females were significantly more active in area three than in area two (p=0.01 and p<0.01) and females were significantly more active in area three than area one (p<0.01). These results suggest that area two was the least active area for males and area three was the most active for females. However, both areas one and two were equally inactive for females and areas one and three were equally active for males. Parrish et al[8] highlighted that it is important to gain an understanding of why female's activity levels are lower than males. During the focus groups, students had mixed responses in relation to whom they played with:

"A bit of both" (participants 1, 3 and 16)

"I like playing with the boys then again I do like playing with girls too" (participant 4)

"Because we play football, a few of the girls play with us but it's mostly boys" (participant 7)

"Boys" (participant 13 and 15)

What is evident is that males and females not only played with different people but also engaged in different activities. Predominantly boys engaged in activities that were seen as moderate-to-vigorous whilst girls engaged in more sedentary activities:

"Sometimes we do like adventurous games, but we do like girly chats and stuff" (participant 2)

"The boys play action games, girls just like walking around" (participant 1)

"Girls like drawing, talking, fussing with their hair and gossiping" (participants 5, 7 and 8)

"We run around more than them, they play ponies and dandy games" (participant 6)

"Making up a dance, skipping and involve handstands and cartwheels" (participant 11)

Results of the focus group are similar to previous studies by Hands et al[34] and Pellegrini et al[20] where they identified that males engaged in more chasing and ball games while females enjoyed jumping or verbal games. During the focus groups males enjoyed football and running around and females enjoyed more sedentary activities such as talking and walking around. Although, it was suggested that girls felt restricted from joining certain activities such as football where they ended up on the side line, due to fear of injury and instead would prefer separate areas.

"I don't like that we don't go in, especially the younger ones as they don't like it" (participant 12)

"A separate part for girls and a separate part for boys" (participant 7 and 10)

"Boys could go play football on the field" (participant 12)

Paechter and Clarke[21] observed similar results, where they identified that girls were more engaged and hence more active when they were on open spaces without being pushed to the side by boys' dominating games such as football. Participant numbers were higher in area three, supporting the results of Paechter and Clarke,[21] where pupils preferred the open spaces, landscape changes and equipment availability.

Equipment usage: A variety of studies have reported increased engagement in PA as a result of introduction of equipment.[21,35] Ridgers et al,[23] identified equipment availability as a positive predictor of moderate PA and a negative predictor of sedentary activity. Findings from the current study indicated that area one (which contained aeroplane themed climbing equipment) found 19% of participants were sedentary and 31% were vigorously active. Area two (that had no equipment and just a sheltered seating area) also reported 19% sedentary behaviour and 35% of

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-145

participants being vigorously active. However, area three (which had a large cobbled area and trim trail) reported that highest percentage of participants (54%) being moderately active (walking) compared to 18% being vigorously active. Overall area three was predominantly used by younger pupils that use more fixed and non-fixed equipment and hence engage in moderate level activity, whereas areas one and two are used by older pupils in chasing and ball game activities and hence engage in more vigorous activity. This is further highlighted throughout the focus group discussions, where students identified that fixed equipment where an opportunity to engage and socialise with friends:

"The slide you can go like go down with other people and it's really fun" (participant 16)

"The slide because you go down all different ways" (participant 14)

"I think we are a lucky school with the plane; it's really fun to climb and drive" (participant 15)

A study by Parrish et al[8] reported that non-fixed equipment created a more cohesive playground environment and had the potential to prevent bullying. However, the current study does not support Parrish et al[8] findings, as fixed play equipment was viewed to relieve boredom and participants reported little interest in non-fixed equipment other than footballs. One possible reason for this is that the school had limited supplies of equipment or the method of using equipment was not efficient in encouraging children to use it. Furthermore, the focus groups were conducted with pupils from years three-to-six and potentially the younger children used non-fixed equipment whereas older children preferred the fixed equipment such as the aeroplane and trim trail. Participants claimed that to increase their PA, equipment suggestions could be:

"It would be good if we were allowed like the rounder's posts out and then we could go on the field and we can all play rounder's" (participant 3)

"Maybe like a roundabout, where you could hold onto poles and maybe you could sit in the middle or something" (participant 4)

"We could have little swings for younger ones and big swings for us and we could have a roundabout that would be quite nice" (participant 7)

"I would like it more if there were more slides" (participant 11)

"The best thing would be more footballs" (participant 13)
As described in a study by Verstraete et al,[24] providing suitable equipment is seen as an effective, low cost method to increase children's PA. Therefore, providing more footballs or rounder's posts may act to increase moderate intensity activity. Additionally, Willenberg et al[35] found that children engaged in vigorous PA when they were provided loose equipment such as footballs, however, not all children identified football as enjoyable:

"I hate football" (participant 12 and 16)

"I see all the boys playing football and I feel like it's going to go right in my eye and hurt they don't let us in sometimes we just stand there" (participant 10)

Finally, health and safety policies may prevent schools from providing swings and additional slides, as this requires risk assessments and additional supervisor training.[35]

Staff supervision*:* Results on the impact of staff supervision on children's PA levels during playtime indicated that supervisors had implemented activities such as skipping and jumping, although this involvement was only reported on four occasions. This limited engagement is therefore not significant enough to be considered reliable. During the focus groups participants explained that you can play with them but they tend to help younger pupils:

"Sometimes they do help play with things like the skipping ropes and stuff with the little kids" (participant 2)

"Sometimes we play with the supervisors but sometimes we play by ourselves" (participant 10)

"If a child doesn't have someone to play with they can go over and get involved in their game" (participant 8)

These findings concur with Ridgers et al[23] report where there was no change in the level of PA as staff were not responsible for the implementation of activities. Instead they allowed children free choice over what activities to engage in. Playground supervision did not appear to significantly affect pupils' activity levels. This may be because pupils identified that lunchtime supervisors are responsible for safety and not helping with activities:

"*To look after us and stop incidents happening"* (participant 7)

"Keeping you safe, first aid" (participant 9)

"They're there to help and look after you" (participant 16)

"If there is an emergency they'll be straight there" (participant 1)

As pupils reported that supervision would not encourage them, results contradict those of Parrish et al[8] where twenty-one pupils reported that teacher interactions would encourage them:

"*We wouldn't play as much if they played"* (participant 16)
"No we wouldn't, I just like talking to them but not playing" (participant 4)

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-145

These results are similar to that of Parrish et al[18] as there were no reported significant benefits if they encouraged children. However, neither study asked supervisors about their knowledge and level of interaction whilst on duty. Overall, results highlighted that lunchtime supervisors are important for health and safety. However, due to size of the play area and only two or three supervisors at one time they do not impact upon PA levels.

Weather: As previously highlighted, the influence of environmental conditions such as the weather on PA is evident.[30] Studies by Chan et al[25] and Goodman et al[29] have reported that children that are outdoors display greater levels of PA compared to when indoors. Results from the current study reports similar findings as participants explain that when they have to come into the village square (indoor area) they are less active due to increased noise, smaller spaces, lack of activities and lack of freedom:

"When it's raining really heavily we normally go into the village square and it's really boring" (participant 10)

"When you're out there (points to playground) you get all the freedom and then in the village square it's only like a tiny space" (participant 12)

"We can't do much because we can't play football because the little ones will get hurt" (participant 7)

"We can sit outside the village square in the hall, in the corridor and then we can like read books and talk" (participant 2)

"We don't get as much to do as the shed but like we can get board games sometimes and sit and play them" (participant 12)

"We don't have as much freedom" (participant 13)

Results of the focus groups describe participants when they are inside due to rain they are less active and engage activities such as reading or talking. As there is little space to play with equipment these findings echoes safety concerns results by Chan et al.[25] However, participants described when it was colder (<5 °C) or hotter (20-32 °C) than usual, their PA levels varied:

"When it's really hot some people usually sunbathe, we do massages and stuff" (participant 3)

"It's good when it's hot because then the footballers get to go on the field and run around" (participant 4)

"It depends but if it's hot you're not very active as you sweat" (participant 8)

"If it's cold we run around more" (participant 16)

"It goes cold and you're like… and you can't run around anymore because you can't even move it's so cold" (participant 12)

Similar to that of Huang and Volpe,[36] during winter days when the temperature was colder, children were reported to spend significantly less time being active. This was often due to having shorter daylight days suggesting children engaged in 9% less activity in winter.[36] On the other hand, when it's hot, participants reported being less active and engaging in more sedentary activities to prevent sweating. This contradicts results from Loucaides et al[37] as participants did not always report being more active in summer months, when it is hotter. However, this does not apply to all participants as some enjoyed the freedom to playing the field - a larger space, during the summer months.

CONCLUSION

The current research study aimed to explore children's PA levels during school lunchtimes through a mixed methods approach combining observations and focus groups. Using an adapted version of McKenzie's[30] SOPLAY provided a systematic way to observe and analyze PA levels of a large number of participants across the 3 tarmac areas. Additionally, the use of focus groups allowed the exploration of how pupils feel their PA levels could be increased building on recommendations from previous studies.[8,13]

Results found that males were significantly more active in area one than area two (p=0.04) and females were significantly more active in area three than area one (p<0.01). Both males and females were significantly more active in area three than in area two (p=0.01 and p<0.01). Overall males were observed to have higher levels of PA during the study, supporting previous studies by Morgan et al.[31] Parrish et al[8] and contradicting those of Mota et al[33] and Santos et al.[38] The impact staff/teacher supervision had upon children's PA was also investigated. Whilst Parrish et al[8] reported that teacher interactions encourage PA the current study reported a limited number of observations where supervisors implemented activities during lunchtimes, through focus group discussions, it became evident that pupils viewed lunchtime supervisors as important for health and safety but rarely encouraged PA. It was also evident that the weather had an impact on PA, where participants claimed that they were less active when it was hotter, supporting Huang and Volpe[36] but contradicting results by Loucaides et al.[37] The study identified how playground PA may contribute to the guidelines of sixty minutes activity per day, with the SOPLAY adapted proforma, but did not directly measure the entire lunchtime. Future studies should further explore the impact supervisors have on lunchtime PA and developing schemes to improve PA without sacrificing health and safety.

Overall the research study has highlighted how PA promotion during lunchtime can encourage children to be physically active and contribute to a child's daily activity levels and health, reducing the risk of becoming overweight or obese.[20,,21,39] Furthermore, it has provided an insight into what children feel will make them more active, positive predictors were equipment and different sections whilst negative predictors were supervi-

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-145

sion and weather. As a result of the current study and previous studies that identified females to have lower PA levels than males[5,8,2,28] continued investigation into the reason for the lack of activity and further analysis on factors that may encourage their PA is needed. Throughout the focus groups a playground leader's scheme was highlighted.[36] Although a large number of the pupils were involved it was apparent that those pupils were not engaged with the initiative, therefore, future studies should identify the aims of the initiative and how pupils can be involved to develop their PA and leadership skills. Finally, as staff/teacher supervision was seen as a negative predictor of PA future studies should further explore the impact supervisors have on lunchtime PA building on the current study as results from Ridgers et al[23] and Parrish et al.[8] Looking at supervisor's knowledge and developing schemes to improve PA without sacrificing health and safety.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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ISSN 2379-6375 Open Journal http://dx.doi.org/10.17140/SEMOJ-3-146

Research

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Volume 3 : Issue 2
Article Ref. #: 1000SEMOJ3146

Article History
Received: March 19th, 2017
Accepted: May 2nd, 2017
Published: May 2nd, 2017

Citation
Kuroda Y, Hudson J, Thatcher R, Legrand FD, Macdermid PW. Motivational state does not affect all-out short duration exercise performance. *Sport Exerc Med Open J*. 2017; 3(2): 40-45. doi: 10.17140/SEMOJ-3-146

Motivational State Does Not Affect All-Out Short Duration Exercise Performance

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ABSTRACT

Introduction: The preferred motivational state (telic or paratelic), i.e., dominance, has been linked to the type of activity sports people participate in. As such, positive or negative performance may occur if there is a mismatch between the activity and the required state. This study set out to examine the effects of altering telic or paratelic motivational states and thus induce the "misfit effect" in order to quantify the influences on emotions and performance during all-out, short duration cycle performance.
Methods: Based on paratelic dominance scale (PDS) scores participants completed the Wingate anaerobic test (WAT) on two separate occasions in their preferred and non-preferred motivational state. Special video display method was used to manipulate participants to their non-preferred motivational state and verified *via* the telic state measure (TSM) test prior to performing the Wingate test (WT). Changes in emotion and stress levels were recorded using the tension and effort stress inventory (TESI) along with heart rate variability (HRV) data obtained from electrocardiogram (ECG). Peak power (PP), mean power (MP) and fatigue index (FI) obtained from the WT were used to assess all-out athletic performance.
Results: The main findings show that there was no link between dominant motivational state and anaerobic cycle performance (p>0.05) and that successful manipulation of motivational state (p<0.05) did not influence perceived levels or physiological levels of stress (p>0.05) and did not affect all-out, short duration cycle performance (p<0.05).
Conclusion: As such, coaches, support staff and athletes do not have to worry about a particular state in regards to telic or paratelic in an acute time frame, as long as the athlete's arousal levels and emotional conditions are optimal.

KEY WORDS: Reversal theory; Performance; Telic-paratelic; Emotions; Manipulating motivational state.

ABBREVIATIONS: ECG: Electrocardiogram; RT: Reversal theory; TD: Telic Dominant; PD: Paratelic; TSM: Telic State Measure; TESI: Tension and Effort Stress Inventory; HRV: Heart Rate Variability; PDS: Paratelic Dominance Scale; WAT: Wingate Anaerobic Test; WT: Wingate Test; MP: Mean Power; FI: Fatigue Index; RMSSDs: Root Mean Square of Successive Heartbeat Interval Differences.

INTRODUCTION

Exercise can have a positive influence on both physical and psychological well-being,[1] which encompasses emotional and stress responses.[2,3] However, this is not the case for all individuals as emotion and stress responses differ among individuals depending on personality and/or exercise mode.[4]

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-146

The reversal theory (RT)[5] has been used to examine individual differences in emotional and physiological responses to exercise[6,7] and proposes that our present motivational state will influence how we interpret our experiences. Eight motivational states exist within RT and have been organised into 4 pairs of bipolar opposites (telic-paratelic, negativist-conformist, mastery-sympathy, and autic-alloic states) that are mutually exclusive, but reversible. Each pair of states is characterised by a distinct underpinning motivational focus and for the telic-paratelic state pair this is 'means and ends'. In the telic (or serious) state the focus is on achieving goals (possibly imposed) and on the future consequences of current experience. Athletes dominant in this state prefer low arousal levels prior to competition.[8] Alternatively, the paratelic state dominant athletes focus on non-essential, freely chosen goals with emphasis on the value of current experiences for their own sake, while lacking regard for future consequences and preferring to be spontaneous.[5] Athletes dominant in this state prefer high arousal levels prior to competition.[9] Interestingly, when the telic dominant individuals are highly aroused, they experience high levels of anxiety as a negative, and similarly if paratelic dominant individuals are not aroused to a high enough level, they experience boredom.

Intertwined within reversal theory are two forms of stress generated internally or externally. These include "tension" which is brought about when preferred levels of arousal, emotions and needs are not met. Increases in this emotion are usually caused by experiencing contingent events (a sudden change in the tone or nature of a situation), frustration situation (when needs are not being met by the current circumstances), and/or satiation (spending a long time in a particular state).[5] The second form of stress is "effort" produced by attempts to reduce tension stress.

As previously intimated, individuals tend to have a preference for one of the paired motivational states and thus spend more time in that state. This is referred to as motivational dominance. Previously, it has been suggested that participating in a non-preferred motivational state (i.e., paratelic as opposed to telic) has negative connotations regarding emotions and ultimately sports performance.[10-12] This mismatched interaction between dominance, state and performance has been labelled the "misfit effect".[13] However, the "misfit effect" does not always occur[14] even though participants were more relaxed in their preferred motivational state.

As such, the aim of the current study is to examine the effects of altering telic or paratelic motivational states and thus induce the "misfit effect" in order to quantify the influence on emotions, stress and performance during all-out, short duration cycle performance. It is hypothesised that during all-out, short duration exercise performance will hampered, present greater levels of stress and negative emotions when performing in the non-preferred (non-dominant) motivational state.

METHODS

PARTICIPANTS

From the initial participant pool of 232 University students, eighteen participants (aged 21.0±5.3 years) were recruited based on their paratelic dominance scores.[15] Selection was based on those participants who scored one standard deviation above the mean (21.42) for paratelic dominance and one standard deviation below the mean (9.91) for telic dominance.[14-16] The telic dominant (TD) group comprised 5 males and 4 females aged 23.3±4.5 years, with a mean exercise frequency of 3.7±1.4 sessions per week. The paratelic dominant (PD) group comprised five males and four females aged 21.8±6.2 years with a mean exercise frequency of 3.9±2.2 sessions per week. All participants provided written informed consent in compliance with the Declaration of Helsinki.[17]

Procedures

Participants attended the laboratory on four separate occasions at the same time of day. The first two sessions were used for familiarization and the third and fourth sessions, administered the experimental trials in counterbalanced order within dominance groups. A cross-over design was employed for each of the two groups, TD and PD, independently.

On arrival at the laboratory the participants' skin was prepared by shaving and cleaning with an alcohol swab before the placement of Ag/AgCl electrodes for electrocardiogram (ECG) measurements. Three electrodes were placed in the left and right intra jugular fossa and one close to the apex of heart.[18] Electrocardiographic activity was recorded *via* bio-amp and PowerLab 4/25 (Model 845, ADInstruments, Castle Hill, Australia) with the ECG signal sampled at 1000 Hz. Participants were instructed to sit on a chair in front of a 1.3 m×1.5 m screen and whereupon they were asked to complete the Telic State Measure test (TSM) in order to determine motivational state (telic or paratelic),[16] with associated arousal and effort levels. The TSM consists of five items to determine motivational state and arousal levels (serious-playful, planning-spontaneous, felt arousal (low-high), preferred arousal (low-high) and effort given for the task (low-high). A rating consists of 6 points with low scores for the first two items indicating a telic state, and high scores indicating a paratelic state. The four items were selected to be used based on previous research investigating similar manipulations of motivational state.[6,11]

Subsequently, the tension and effort stress inventory (TESI)[19] was completed in order to determine tension and effort stress along with measures of emotion (relaxation, anxiety, excitement, and boredom[14]) prior to performance. TESI consists of 20 items to measure stress (tension and effort) and pleasant or unpleasant emotions. of the inventory uses a seven points scale ('not at all' equaling 1 and 'very much' equalling 7) for each

ISSN 2379-6375

http://dx.doi.org/10.17140/SEMOJ-3-146

item. For this study we examined stress and four somatic emotions (anxiety, excitement, boredom and relaxation), which is emotion associated with exercise.[20]

ECG was measured for 5 min whilst the video manipulation was administered.[14]

Participants then completed a 5 min warm up during which they completed a second TSM and TESI, used as a state manipulation check (pre-performance) followed by the 30 s all-out Wingate cycle sprint test[21] using a Lode Excalibur Sport cycle ergometer (Groningen, Netherlands).[22] For male participants the linear factor was set at 0.069, and for female participants 0.049.

Data Analysis

Raw ECG data were edited and heart rate variability (HRV) analyses were performed using HRV Module for LabChart v1 for Windows (ADInstruments, Castle Hill, Australia). QRS complexes were identified as follows: normal, ectopic or artefact. A configurable R wave threshold detector automatically identified every heartbeat. Normal-to-normal interbeat interval (RR) intervals were calculated for HRV. Ectopic beats were replaced using linear interpolation of prior and succeeding normal intervals for the analysis. For the time domain analysis, the mean NN interval, root mean square of successive heartbeat interval differences (RMSSDs) and pNN50 were computed. The non-parametric method, spectrum of intervals, where RR intervals are re-sampled and interpolated at intervals equal to the average period, was used to determine the frequency domain.[18] The fast fourier transform (FFT) of 1024 point to overlapping segments of the resampled RR data with a Hanning window for minimal spectral leakage was applied to calculate each power spectrum for a 5 min epoch. For frequency domain analysis was quantified through power spectral density of very low frequency (VLF), low frequency (LF) and high frequency (HF).

Data is presented as mean±SD, with a two-way (motivational dominance*motivational state) repeated measures analysis of variance (two-way ANOVA) enabling comparison of variables measured for motivational dominance and state at pre-performance. Each factor had two levels including: telic dominant in a telic state (TD-T); telic dominant in a paratelic state (TD-P); paratelic dominant in telic state (PD-T); and paratelic dominant in a paratelic state (PD-P). A Tukey post-hoc analysis was performed to identify specific condition differences where a main effect was present.

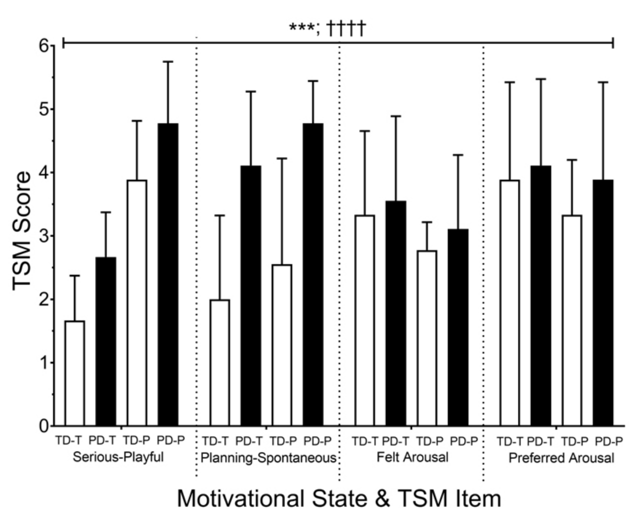
All statistical analyses were performed using Prism V6.0f, Graphpad, CA, USA, significance set at $p<0.05$.

RESULTS

The paratelic dominant group scored significantly higher than the telic dominant group on total Paratelic Dominance Score (TD: 5.78±3.11; PD: 23.44±0.98; $t_{(16)}$=-16.23, $p<.001$).

The intervention to change motivational states of each group prior to performing the Wingate Test presented a significant ($F_{(9, 72)}$=7.134; $p<0.0001$) interaction, TSM dominance*motivational state, with a main effect difference for motivational state ($F_{(3, 24)}$=11.89; $p<0.0001$) but not TSM dominance ($F_{(3, 24)}$=0.9713; P=0.423). Post-hoc differences were identified ($p<0.05$, Figure 1) for the items: serious-playful for TD:TS *vs.* TD:PS, PD:TS *vs.* PD:PS, and TD:TS *vs.* PD:PS; planning-

Figure1: Mean±SD Scores for the Telic State Measures Test Separated for Normal-Dominant State \(telic (TD), or Paratelic (PD)) and Manipulated State. Where, refers to Significant (p<0.001) Interaction between Motivational Dominance and Motivational State; and †††† Refers to a Significant (p<0.0001) Main Effect of Motivational State.



ISSN 2379-6375

http://dx.doi.org/10.17140/SEMOJ-3-146

Table 1: Mean±SD for Performance Metrics from the Wingate Anaerobic Test Under Normal-Dominant State and Manipulated State Prior to Testing.

Dominant State	Motivational State	Peak Power (W)	Mean Power (W)	Fatigue Index (%)
Telic	Telic	995±234	548±151	64.6±10.2
	Paratelic(m)	922±187	523±119	60.7±13.2
Paratelic	Telic(m)	1075±248	554±196	69.3±8.2
	Paratelic	1059±294	551±195	69.4±8.8

spontaneity for TD:TS *vs.* PD:TS, TD:TS *vs.* PD:PS, TD:PS *vs.* PD:PS.

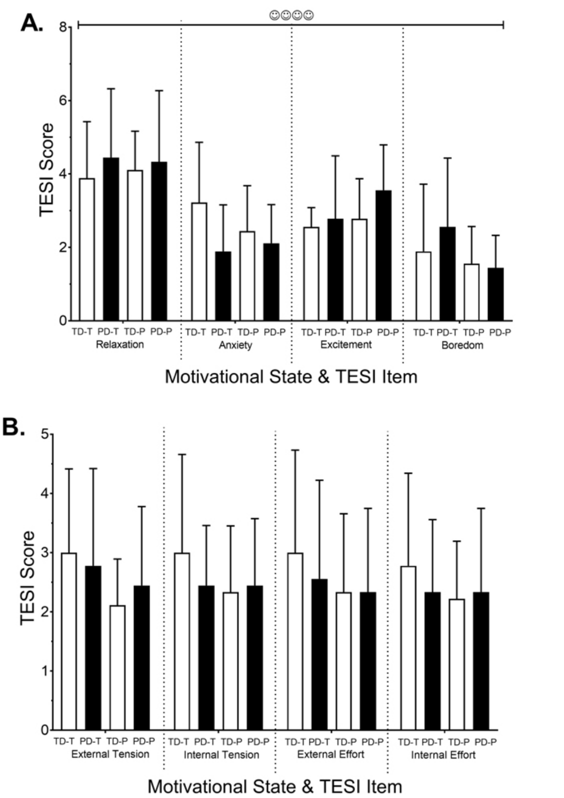
Subsequently, performance during the Wingate Anaerobic test did not differ when comparing for motivational state ($F_{(1, 8)}$=1.027, *P*=0.341; $F_{(1, 8)}$=1.072, *p*=0.331; $F_{(1, 8)}$=0.743, *p*=0.414) or between telic or paratelic dominance ($F_{(1, 8)}$=0.678, *p*=0.434; $F_{(1, 8)}$=0.041, *p*=0.845; $F_{(1, 8)}$=3.119, *p*=0.115) for peak power, mean power or fatigue index, respectively (Table 1).

Interestingly, there were no significant (*p*>0.05) main effects of motivational dominance or motivational state on indices of the TESI (Figures 2A, 2B). In support of the TESI data, there were no statistical differences (*p*>0.05) amongst the physiological variables used (Table 2) to assess participant stress levels in either motivational state.

DISCUSSION

This study set out to examine the effects of altering telic or paratelic motivational states in order to quantify the influence on emotion, stress, and performance during all-out, short duration cycling. The main findings show that: a) There was no link between dominant motivational state and anaerobic cycle performance; b) Manipulating motivational state to the opposite state did not influence perceived levels or physiological levels of stress and did not affect anaerobic cycle performance.

Figure 2. Mean±SD Scores for the Tension and Effort Stress Inventory, Separated for Normal-Dominant State (Telic (TD), or Paratelic (PD)) and Manipulated state. A) Illustrates emotion scores, and B) Stress Scores. Where, refers to a significant (p<0.0001) main effect of TESI item.



ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-146

Table 2: Mean±SD for Heart Rate and Heart Rate Variability Variables Under Normal-Dominant State and Manipulated$^{(m)}$ State Prior to Performing the Wingate Anaerobic Test.

Variable	TD-T	TD-P$^{(m)}$	PD-T$^{(m)}$	PD-P
Mean HR (bpm)	74±7	71±9	77±12	73±7
Mean NN (ms)	820.3±79.1	852.9±93.2	797.6±112	830.5±80.5
SDNN (ms)	45.3±14.2	48.3±8.8	46.2±17.4	54.1±15.4
RMSSD	32.87±13.5	35.6±15.3	31.2±17.0	35.3±13.2
NN50	15.2±11.6	20.9±16.5	13.6±15.4	17.5±14.7
VLF [DC-0.04Hz] (ms^2)	637± 441	995±737	901±213	1076±839
LF [0.04-0.15Hz] (ms^2)	796±438	678±434	763±528	1150±573
HF [0.15-0.4Hz] (ms^2)	434±272	496±316	420±485	538±575
LF: nu (%)	62.5±15.0	55.1±19.8	64.8±11.1	66.7±16.5
HF: nu (%)	31.6±12.7	36.2±12.8	28.9±11.1	26.6±14.6
LF/HF	2.62±1.91	2.01±1.65	2.67±1.34	3.92±3.42
LF (Normalize %)	99.1±55.6	105.0±46.3	135.5±130.2	122.2±64.1
HF (Normalize %)	86.9±39.7	91.99±16.1	129.6±127.4	140.9±96.5
LF/HF (Normalize %)	121.5±71.0	114.67±48.2	114.8±65.5	121.17±181.8

VLF: Very Low Frequency; LF: Low Frequency; HF: High Frequency; HR: Heart rate; SDNN: Standard deviation of normal to normal R-R intervals; RMSSD: Root mean square of successive heartbeat interval difference; NN: normal RR.

The results presented here further the questions raised regarding preference for physicality of sporting events and motivational states (telic *vs*. paratelic) and exercise mode. Though the trials were performed in a counter-balanced, cross-over manner, it is important to emphasise that there was no difference between performance for telic or paratelic dominant groups i.e., there was no advantage for performance measures in the Wingate test for paratelic over telic dominant groups. This is contrary to previous research that suggests that telic dominant individuals are more likely to excel in endurance events whilst paratelic dominant individuals excel in more explosive events such as the laboratory test used here.[20,23] Explanations for these findings could centre around the sensitivity of the inventories used[14] as participant groups did not differ significantly in their preferred states for scores related to emotions (relaxation, anxiety, excitement and boredom). However, the findings while not significant did suggest that the telic dominant group had higher mean values for anxiety than paratelic group at the outset of this study. High levels of this emotion have been previously suggested[8] to inhibit performance. As such it might have been expected the difference within the normal, preferred state to be even greater than normal. Likewise, the paratelic dominant group also showed tendencies for greater excitement and lower boredom pre-performance within the present study which reportedly should improve performance in all-out, short duration events. To a certain extent this did occur as peak power scores where non-significantly greater for this group, supporting links to measures of explosive, maximal exercise performance[20] associated with fast twitch muscle fibres.[15] However, the low anxiety levels in this groups would likely reduced overall performance.[9]

Individually determined motivational states (telic-paratelic) were successfully manipulated to the opposite state ("misfit effect") prior to exercise performance as per previous studies[14,24] using video stimuli. Unexpectedly, the misfit effect did not affect all-out, short duration cycle performance. As per the non-significant difference between preferred state dominance groups and performance already discussed, perceived emotions *via* assessed TESI showed no intra-group differences for relaxation, anxiety, excitement, boredom or tension and effort.[10] Again, interesting and maybe worth exploring in future work is the level of changes that occurred. Non-significant increases in boredom as a result of a decrease in excitement for paratelic dominant participants occurred but wasn't enough to alter performance. However, the non-significance finding is supported by physiological measures of stress. As such it may be prudent to focus on manipulation of arousal levels. Additionally, the manipulation of motivational state acutely as per this study is likely limited compared to long-term manipulation where changes would likely lead psychophysiological changes, hormonal in nature. As such it is envisaged there would be a greater overarching effect on performance, perceived and physiological markers of stress.

CONCLUSION

This aims of this study were to assess the effects of altering telic or paratelic motivational states in order to quantify the influence on emotion, stress, and performance during sprint exercise. The data presented shows no link between dominant motivational state and advantageous all-out, short duration cycle performance. Additionally, the manipulation of participants, motivational state to the opposite state, had no bearing on performance outcome, perceived levels or physiological levels of stress.

As such, coaches, support staff and athletes do not have to worry about a particular state in regards to telic or paratelic in an acute time frame, as long as the athlete's arousal levels and emotional conditions are optimal.

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-146

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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ISSN 2379-6375 Open Journal http://dx.doi.org/10.17140/SEMOJ-3-147

Research

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Volume 3 : Issue 2
Article Ref. #: 1000SEMOJ3147

Article History
Received: May 11th, 2017
Accepted: June 5th, 2017
Published: June 6th, 2017

Citation
Cosio-Lima LM, Crawley A, Adlof LE, Straughn M, Wallop JD, Lee Y. Effects of a periodized training program and a traditional military training program on functional movement and Y-balance tests in ROTC cadets. *Sport Exerc Med Open J*. 2017; 3(2): 46-52. doi: 10.17140/SEMOJ-3-147

Effects of a Periodized Training Program and a Traditional Military Training Program on Functional Movement and Y-Balance Tests in ROTC Cadets

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ABSTRACT

Background: Functional movement screening (FMS) and Y-balance test (YBT) are assessment procedures used to examine the 'quality' of movement patterns and identify individuals that might have specific limitations or asymmetries. Low FMS and YBT scores have been linked with a higher risk of injury among athletic populations. Since FMS and YBT are becoming more widely used screening tools, it is important to examine the various training programs that could improve FMS and YBT scores.
Purpose: This pilot study examined the effects of a 10-week periodized and traditional military training program on FMS, and upper and lower quadrant YBT scores of Reserve Officers Training Corps (ROTC) Cadets.
Methods: Subjects consisted of 36 Army and Air Force ROTC cadets (male=24, female=12), Age 19.7(yrs)±5.96, Height (cm)=175.7±9.28, Weight(kg)=75.70±13.41. The periodized, intervention group (IG n=24) trained for 1 hour/day, 4 days/week and the control group (CG n=12) participated in traditional ROTC training protocol for 1 hour/day, 3 days/week. A 2×2 mixed factorial analysis of variance (ANOVA) was used to compare mean change values of the FMS, upper, and lower quadrant YBT scores for intervention and control groups.
Results: A significant interaction ($p \leq 0.05$) was observed for FMS scores. The control group had a much lower initial FMS score and demonstrated more improvement than the intervention group. Both groups demonstrated a significant increase in left side YBT upper ($p=0.03$) and lower ($p=0.02$) quadrant scores after 10-weeks of training.
Conclusions: Since FMS and YBT scores are being used more frequently as screening tools for risk of injury, it is important to study methods that will improve FMS and YBT scores in diverse athletic populations. This study found larger improvements in FMS scores in ROTC cadets participating in a traditional military training program compared to cadets participating in a periodized strength training program. Scores in the left side of the YBT upper and lower quadrants were improved in both groups suggesting multiple training programs can improve function in non-dominant sides or asymmetries. Future studies are warranted and should address certain limitations that this study encountered (sample size and length of training period). Further exploration of FMS and YBT scores and mechanisms of improvement in tactical athletic populations would be beneficial.

KEY WORDS: Military training; Periodized training; FMS; YBT.

ABBREVIATIONS: FMS: Functional Movement Screening: YBT: Y-Balance Test; NMTP: Neuromuscular training program; ROTC: Reserve Officers' Training Corps; ANOVA: Analysis of variance.

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-147

INTRODUCTION

Screening tools developed to predict injury in various athletic populations, like the functional movement screen (FMS) and the Y-balance test (YBT), are increasing in popularity.[1,2] The FMS and the YBT identify individuals who have functional limitations, or asymmetries by examining the ability of the subject to perform very specific movements.[1,3,4] The YBT device has a stance platform from which three pieces extend in the anterior, posteriomedial, and posterolateral directions, forming a "Y" shape. In the lower quarter Y-balance test (YBT-LQ) the participant pushes the reach indicator with the foot of his or her reach limb allowing the tester to take measurements of the reach distance.[5] The upper quarter Y-balance test (YBT-UQ) measures the ability of the subject to reach with the free hand while bearing weight on the contralateral upper limb.[5] Tests like these that have the ability to predict injuries, are used as screening tools in various athletic settings.[6,7] Low scores in these tests have been linked to higher risk of injuries in athletic populations.[8,9]

As military personnel regularly engage in physical training to improve performance, it is important to assess the risk of injuries and the methods used to train these athletes. Previous studies have examined the effects of varied neural and individualized training programs associated with FMS scores, but no studies to date have investigated a periodized training program in relationship to FMS and YBT scores. Studies have examined the effects of neural training methods and individualized corrective programs on FMS scores in various athletic and tactical populations.[10,11] Linek et al[10] found increased FMS scores among volleyball players subsequent to an 8-week training program based on the Neuromuscular Activation (NEURAC) method. Similarly, Stanek et al[11] found increased FMS scores in firefighters upon completion of an 8-week individualized corrective exercise program. Being that adaptations to exercise are specific to the training method used,[12] it is important to assess the impact of various training methods used in military populations as they relate to risk of injury.

There is limited research regarding the impact of various training methods in relationship to injury risk assessments, thus the purpose of the current pilot study was to examine the effects of a 10-week periodized resistance training program on FMS, YBT-LQ and YBT-UQ scores of ROTC cadets compared to a traditional military training program. Specifically, the hypothesis is that the periodized resistance program will lead to higher injury risk assessment scores (FMS, YBT-LQ and YBT-UQ) in ROTC cadets.

METHODS

Study Design

FMS, YBT-LQ and YBT-UQ scores of ROTC cadets were measured pre and post a 10-week training program. A control sample of the cadets performed the traditional military training protocol while an intervention sample performed the periodized training program. Results were compared to determine the level of improvement in scores after completion of the training program.

SUBJECTS

Subjects consisted of 36 Army and Air Force ROTC cadets (male=24, female=12: age 19.7±5.96 yrs; height, 175.7±9.28 cm; weight, 75.70±13.41 kg) from the University of West Florida (Pensacola, FL, USA). The research staff briefed potential ROTC cadets on the purpose of the study and potential volunteers wrote their name and contact information on a list. Volunteers were contacted *via* email and a baseline meeting was set where procedures were explained. Volunteers were briefed about the objectives and risks. Institutional approval was granted through the University of West Florida Institutional Review Board (IRB) and volunteers gave written informed consent prior to participation. Subjects were grouped using a convenience sample meaning, those whose schedule did not allow them to participate in the periodized training program were assigned to the control group. The intervention group (IG, n=24) followed a periodized training program for 1 hour/day, 4 days/week and the control group (CG, n=12) participated in a traditional military training protocol for 1 hour/day, 3 days/week. A sample week of the periodized program is shown in Table 1.

Procedures

Prior to starting the program, age and physical characteristics were obtained and all cadets were measured for body mass and height. Height was measured to the nearest centimeter using a stadiometer and weight was measured using a SECA platform scale (Chino, CA, USA). Body mass index (BMI) was calculated by dividing the subject's weight by the height squared (kg/m^2).

The FMS and upper and lower body YBT screenings were completed prior to starting training and after 10 weeks of training. A strength-and-conditioning specialist, certified in FMS and YBT testing, monitored the research staff during all examinations. Before testing sessions, the strength-and-conditioning specialist conducted practice testing sessions among the research staff to ensure homogeneity of inter-rater reliability. Research staff members were assigned to only one test and performed that same test both pre- and post-training. FMS and YBT scoring sheets were given to all participants who then carried them throughout the testing session until they were collected at the end of testing for data entry. Cadets performed the tests in standard military t-shirt, shorts, socks, and sneakers (or without shoes where appropriate). The FMS and YBT assessments were performed in random order once height and weight were recorded.

The seven FMS protocols were administered using the FMS test kit.[6,7] Each test was scored on a 4-point ordinal scale (0 to 3). The seven movements (one score for each) were summed

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-147

Table 1: Sample Week of Periodized Training Program for the Intervention Group.

Sample Week of Training Program				
Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Dynamic Warm-up: 10 minutes **Strength:** (85% 1RM) Back Squat 4x5-6 Bench 4x5-6 (Perform a warmup set of 10 at 50-60% of 1RM) **Accessory:** Lat-Pulldown: 3x10+1 set to failure Tricep Push down: 3x10 +1 set to failure Inverted Row: 3x10+1 set to failure Push ups: 3 Max rep sets (2-3 min rest between sets) **Cooldown:** Full body stretching	**Dynamic Warm-up:** 10 minutes **Speed/Conditioning:** (3 rounds as quickly as possible with 1 minute rest between each station) 15 Burpee Box Jump Over 50 foot farmers carry (heavy) 30 Strict shoulder press (45/35lbs) 50 foot farmers carry (heavy) 20 Overhead Weighted Walking Lunges (45/35lbs) **Core work:** (3 rounds, keep moving at a consistent pace) 30 second hollow holds 5 wall walks 30 sit ups 30s Side planks **Cooldown:** Full body stretching	**Rest Day**	**Dynamic Warm-up:** 10 minutes **Strength:** (85-87% 1RM) Power Cleans 4x4 Deadlift 4x5-6 Front squat 4x5-6 **Power:** 3 rounds–perform movement as quickly as possible then rest until the next minute. Min 1: Full gym sled push (90/45lbs) Min 2: 15 Kettlebell Swings (heavy) Min 3: 20 Air squats Min 4: 20 Push ups **Cooldown:** Full body stretching	**Dynamic Warm-up:** 10 minutes **Work Capacity:** 16 min–complete as many rounds as possible. 1200 m run 15 Sit ups 15 Weighted Front squats (40-50% 1RM) 20 min–complete as many rounds as possible while increasing reps by 1 each round. 5 box jumps 10 Kettlebell swings 15 wall balls (20/14lbs) **Cooldown:** Full body stretching

Strength and accessory work were complete using supersets for time efficiency.

for a total score that varied from 0 and 21. FMS tests were administered to candidates in a single session in accordance with the standard FMS criteria.[13] The criterion for a successful movement was demonstrated by the administrator prior to each test.

The YBT was administered with a commercially-available device that formed a figure "Y" and had sliders on each arm of the "Y" (Move2Perform, Evansville, IN, USA).[3,4] For the YBT-LQ, the participant pushed the reach indicator with the foot of one limb, while the other foot remained stationary on the device. The tester obtained the reach distance.[5,14] The YBT has demonstrated high intra-tester (0.85-0.89) and inter-tester reliability (0.97-1.00).[15] The movements were demonstrated by the testers and subjects were provided with 1-2 practice trials prior to performing the test. Subjects were given three criterion trials, and the best performance was recorded to the nearest half centimeter. For the YBT-LQ measures, participants stood with one foot flat at the junction (toes at the center line) of the three parts of the "Y". While maintaining balance, and without their reaching foot touching the ground, the participant slid the bar on each of the three parts of the "Y" (anterior, posteromedial and posteriolaterial) one part at a time. The right and left feet were tested separately. For the YBT-UQ measures, the participant assumed a push-up position with one arm on the junction (thumb at the center line) of the "Y". With the free arm, participants pushed out the slide as far as possible on the three different bars (one bar at a time) while maintaining the push up position and not touching the ground with their free hand. The right and left arm were tested separately. To normalize for limb-length differences among subjects, YBT upper and lower maximized reach distance (MAXD) was calculated with the following formula: ([excursion distance/limb length]x100).[5] Composite reach distance was calculated taking the average distance in the three reach directions, dividing by limb length and multiplying by 100 (average distance in the three directions/limb length)x100 [16] Upper-limb length was measured as the distance from the C7 spinous process to the most distal tip of the middle finger (in centimeters) with a tape measure with the limb abducted to shoulder height (90º). Lower-limb length was measured from the anterosuperior iliac spine to the medial malleolus.[16]

Participants in the intervention group began the periodized training program subsequent to completing the pre FMS and YBT testing. The control group participated in their regular military training program and schedule. As participation in physical training is a requirement for ROTC cadets, attendance was monitored for both groups by the ROTC and study research staff resulting in regular levels (85% of the sessions) of participation.

ROTC Training Programs

Cadets in the intervention group participated in a four-day-per-week (Mon, Tues, Thur, Fri) training program that incorporated strength, speed/conditioning, strength/power and work capacity (ability to use any physical quality for an extended period of time). Periodized resistance training workouts were developed to enhance muscular strength and power (e.g., squats, cleans, bench press, push press) while also targeting push-ups, sit-ups and running which are required for the military physical fitness tests. There was an emphasis on structural exercises such as squats, deadlifts, power cleans, military press and bent-over

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-147

rows targeting both upper- and lower-body musculature.

The order of exercises progressed from power to multi joint to single joint. Volume was dictated by the resistance load, number of sets and number of reps for each workout. Speed-and-conditioning-development days were programmed to target neuromuscular function and operational readiness with multiple types of training methods, including plyometrics and high intensity interval training, and implements like medicine balls, weight sleds, kettlebells and sand bags. Work-capacity days focused on improving cadet's ability to resist the onset of fatigue and improve recovery rates from high-intensity exercise. All training sessions were preceded by a 10-minute dynamic warm-up (high knees, monster walks, lateral shuffles, carioca, walking lunges, inch worms, bear crawls, etc) and followed by a cool-down of full-body static stretching. All training sessions were 60 minutes in duration and were supervised by a strength-and-conditioning professional.

Cadets in the control group participated in the regular ROTC physical training that consisted of 60-minute sessions performed three days per week. This training was focused on developing the physical abilities (push-ups, sit-ups, running) necessary to pass the required physical fitness tests. These sessions involved a warm-up followed by a combination of moderately- and vigorously-intense aerobic activity with progressive increases in the time spent in continuous exercise. Cadets then participated in a muscular-fitness-development segment using movements that worked the whole body including calisthenics, plyometrics and field exercises. All sessions were completed with a cool-down that involved static stretching for flexibility.

Statistical Analysis

Descriptive statistics were calculated for physical characteristics, total FMS scores, and total YBT scores. A 2x2 mixed-factorial ANOVA was used to compare mean-change values of total FMS and YBT scores for intervention and control groups. Effect size was interpreted using Cohen[17] (1988, pp. 284-7): 0.01=small effect, 0.06=moderate effect, 0.14=large effect. Statistical Package for the Social Sciences (SPSS, Version 18, Chicago, IL, USA) was used for statistical analysis with an alpha level set at $p<0.05$.

RESULTS

Mean-change values of total FMS and YBT scores for experimental and control groups are shown in Table 2. A significant interaction F (1,34)=8.82, $p<0.05$ was observed for pre- and post-FMS scores and group assignment. The mean difference in FMS scores was 1.33 with a 95% confidence interval ranging from 0.76 to 1.90. The partial eta square statistic (.21) indicated a large effect size. A significant main effect was observed for pre- and post-FMS scores, F (1,34)=22.58, p=0.000. The mean difference in FMS scores was 0.42 with a 95% confidence interval ranging from -1.31 to 1.21. The partial eta square statistic (0.40) indicated a large effect size. While both groups increased in FMS scores after 10 weeks of training, the control group presented with a much lower initial score and demonstrated a larger improvement than the intervention group.

The interaction between group assignment and lower left quadrant YBT test was not statistically significant, F (1,34)=0.02, p=0.89. The mean difference in lower left quadrant YBT scores was 2.28 with a 95% confidence interval ranging from -2.83 to 7.34. The partial eta square statistic (0.00) indicated a small effect size. There was a significant main effect F (1,34)=5.55, p=0.02 between lower left YBT quadrant and pre and post-testing. The mean difference in from pre- to post-scores was 2.18 with a 95% confidence interval ranging from 0.30 to 4.06. The partial eta square statistic (0.14) indicated a large effect size.

The interaction between group assignment and upper left quadrant YBT test was not statistically significant, F

Table 2: 2x2 Repeated Measures ANOVA Mean Change Values of Total FMS and YBT Scores for Experimental and Control Groups.

Test	Group	Mean±SD		ANOVA		
		Pre-measures	Post-measures	Group *p*-value	Pre-post *p*-value	Group X pre-post *p*-value
FMS total score	Control intervention	14.75±1.76 15.54±1.96	16.92±1.38 16.04±1.88	0.94	<0.00*	<0.05*
YBT lower body right side	Control intervention	99.86±9.37 98.97±7.36	99.22±6.89 100.42± 6.95	0.95	0.69	0.29
YBT lower body left side	Control intervention	96.78±8.39 98.92±7.74	98.83±7.21 101.24±7.16	0.37	0.02*	0.89
YBT upper body right side	Control intervention	93.72± 9.48 92.95± 7.90	96.10±9.65 94.84±6.83	0.67	0.11	0.85
YBT upper body left side	Control intervention	93.08±9.26 91.50±8.16	94.83±9.02 95.43±7.30	0.85	0.03*	0.39

*Significance was set at the 0.05 alpha level.

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-147

(1,34)=0.75, p=0.39. The mean difference in upper left quadrant YBT scores was 4.96 with a 95% confidence interval ranging from -4.84 to 5.83. The partial eta square statistic (0.02) indicated a small effect size. There was a significant main effect, $F(1,34)=5.12$, p=0.03. The mean difference in from pre- to post-scores was 2.84 with a 95% confidence interval ranging from 0.29 to 5.39. The partial eta square statistic (0.14) indicated a large effect size between upper left YBT quadrant and pre- and post-testing. Both intervention and control groups experienced significant increases post training in upper and lower left quadrants YBT scores.

DISCUSSION

The purpose of this research was to examine the effects of two 10-week physical training programs in relationship to FMS, YBT-LQ and YBT-UQ scores of ROTC cadets. The findings do not support the hypothesis that a periodized resistance training program would result in different injury-risk-assessment scores when compared to a traditional military training program. Specifically, significant improvements were seen in both the periodized and the traditional training groups for total FMS scores and upper and lower left YBT quadrants scores.

Since both programs were designed to address all major muscle groups and movement patterns required for military populations, it is relevant to note the main differences between the two training protocols. The traditional military training program focused on running, general body-weight exercises, and repetitive practice of the push-ups and sit-ups required for physical testing. The periodized training program involved a greater variety of equipment and exercise modalities and used a very specific resistance-training progression protocol. The traditional military training protocol was only performed three days per week in comparison to the four-day-a-week periodized training model. Based on the current results, we can suggest that regular participation in a three day-a-week training program was sufficient to increase FMS and YBT left side scores.

This is not the first research to investigate the relationship between different exercise programs and injury-risk assessments. The FMS and YBT tests have been widely used as a screening tool to predict risk of injury in athletic and military populations.[8,13,18] As a result, several studies have tested training programs geared toward the improvement of balance and locomotion to improve FMS scores.[10,11,19] Researchers have also focused on developing programs based on each participant's individual weaknesses on the FMS total score. Stanek et al[12] demonstrated significant improvement in total FMS scores after an individual eight-week intervention that focused on stability and mobility. While prescribing individual exercise programs is certainly ideal, the drawback of adding additional individual exercises into any group-training regimen has a negative impact on time management and efficacy. Based on the results of the current research, alternative-group training methods have the capacity to enhance FMS and YBT scores. Therefore, it is important to continue to investigate the relationship between various training methods and FMS and YBT tests scores.

In the present study, both the intervention and control group presented improvements in FMS and left-side upper and lower YBT scores. To our knowledge this is the only study to examine the effects of a periodized training program on FMS and upper-and lower-quadrants YBT scores of ROTC cadets. Because of scarce research including intervention and control groups on training programs to improve FMS and YBT scores, it is difficult to compare our results with previous literature with the current study.

While in the present study the intervention group showed lesser improvement in FMS scores than the control group, it is worth noting that our results are consistent with other studies where an exercise intervention was used to improve FMS scores.[8,11,19] As mentioned above, Stanek and colleagues[11] observed improved FMS scores in firefighters after an 8-week individualized workout program. The researchers used the FMS Pro-360 software program that prescribed exercises that enhance mobility followed by static and dynamic control and strength exercises.[11] Several of the exercises used by the FMS Pro-360 software are similar to the exercises prescribed in this study (shoulder mobility, planks, single leg squats) for the intervention group.

Similar studies have examined the effects of alternative interventions on FMS scores.[19,22,23] Cowen used yoga as an intervention in firefighters and found increases in FMS scores after six-weeks of participation. Kiesel[19] studied the effects of an off-season resistance training program on professional football players and observed increases in FMS scores subsequent to participation. The limitation of the study by Kiesel et al[19] was the lack of a control group making it difficult to establish a cause/effect relationship. More specific to the current population, Goss et al[22] observed improvements on FMS scores in special-operation soldiers after a 6-week functional training program. Our findings were consistent with these three studies. Both groups in the present study experienced improvements in FMS scores after participation in a training program. We can stipulate that a consistent exercise routine that incorporates multiple modes of exercise will influence proprioception activation and fundamental movement/balance that will result in a positive influence on FMS assessments. In the present study, exercises like planks, push-ups and different forms of sit-ups and crunches that would stimulate core activation were used by both groups. These general, non-specific exercises might influence fundamental movement patterns and asymmetries that the FMS measures. It is worth noting that these are fundamental components of human movement and are not necessarily sport specific. Further research is warranted to test the degree of influence of each exercise stimulus in relationship to FMS scores in multiple athletic populations.

Both groups in the present study had significant improvements in the left side of the YBT, upper and lower quad-

ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-147

rants. To our knowledge, this is the first study that examined the impact of a periodized training program and a traditional ROTC training program on upper- and lower-quadrant YBT scores in ROTC cadets. The results of our study are similar to research by Filipa and colleagues[24] where an improvement in the star excursion balance test was observed in female soccer players following eight-weeks of a neuromuscular training program (NMTP). The NMTP focused on lower-extremity strength and core stability. The researchers found that star excursion balance test (SEBT) improved with neuromuscular and proprioception training. Similarly, subjects in both groups of the present study performed exercises like planks, plyometrics, single-leg squats, and RDLs that could have improved neuromuscular activation leading to better YBT-LQ scores.

Interestingly, the gains in YBT-LQ balance scores observed in the present study occurred in the non-dominant side or, in this case, the left side. The majority of the ROTC cadets in the present study were right-side dominant. The gains in a non-dominant side observed in the current study concur with findings from by Hudson et al,[25] who determined normative YBT-LQ scores by assessing 90 healthy (19.6±1.2 y/o), collegiate female volleyball players. Baseline values for this population were 94.1±6.6% on the dominant limb and 93.9±6.2% on the non-dominant limb. We can hypothesize that the higher improvements in lower-and-upper quadrant YBT scores that were observed in the non-dominant side after consistent training was due to the lower scores observed in both groups before their training programs. Again, it is problematic to compare our results with other studies since limited research has been conducted regarding the YBT-UQ test and its relationship to muscular strength. Borms et al[26] investigated the relationship between shoulder and elbow flexion and extension on YBT-UQ performance in 29 male and female overhead athletes. It was observed that performance on the YBT-UQ was not related to upper-limb strength. Therefore, the gains observed in both groups in the left YBT-UQ could be attributed to consistent whole-body mobility and stretching that was performed at the end of each training session for both the intervention and control groups. Further research needs to be conducted to better understand the relationship between strength and mobility and the YBT-UQ test.

The present study encountered several limitations that need to be addressed. This study did not have a control group that did not engage in a training program to account for the influence of test/re-test. The majority of ROTC cadets engage in physical training in order to pass their physical fitness tests, and because of the small sample size in the current study it was not an option to ask the cadets to abstain from physical activity. A larger sample size could have been more representative of the general ROTC population. There were only 12 females that participated in this study *versus* 24 males and all female participants were in the intervention group. Future studies should have equal number of females in a control group to make more valid comparisons among genders. Due to scheduling constraints, a convenience sample was used to split the study participants into the intervention and control group. Another possible limitation was that the researchers in this study were not able to supervise the traditional military training performed by the control group. It is possible that cadets in the control group performed additional training on their own time, which could have influenced the results of the post-tests. Future studies that address these limitations are warranted.

CONCLUSION

In conclusion, the present study showed that both a periodized and traditional training program resulted in similar changes in FMS scores and left-side YBT scores for the upper and lower quadrants. The results of this study suggest that a three-day-a week, traditional military training program is sufficient to improve upper and lower YBT and FMS scores in ROTC cadets. Future research is necessary to better determine the relationship between various training methods and their ability to improve FMS and YBT scores among military and athletic populations.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-147

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ISSN 2379-6375 Open Journal http://dx.doi.org/10.17140/SEMOJ-3-148

Case Study

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Volume 3 : Issue 2
Article Ref. #: 1000SEMOJ3148

Article History
Received: May 4th, 2017
Accepted: June 5th, 2017
Published: June 6th, 2017

Citation
Sugiyama K. Blow rifle: A healthy new sport. *Sport Exerc Med Open J*. 2017; 3(2): 53-57. doi: 10.17140/SEMOJ-3-148

Blow Rifle: A Healthy New Sport

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INTRODUCTION

Aging society has been considered as one of the most important problems in Japan. Japanese total annual expenditure on national healthcare in fiscal 2013 exceeded 40 trillion yen ($333 billion) for the first time, reflecting the growing number of elderly people.[1] Doing regular moderate activities both exercise and sports has lot of benefits for health and would improve the physical fitness and quality of life (QOL).This would also reduce the cost of healthcare. Now-a-days, in Japan, most popular exercise for the elderly people is walking. According to the report of Japan's Ministry of Health, Labour and Welfare, 50.8% people include walking as exercise for their daily health and general fitness.[1] The percentage found in 2013 was 2 times more than that in 1994.[1] Although, health awareness has been increasing in Japanese people, in general, it is well known that it would be impossible to improve the strength fitness with merely walking. It is reported that the risk of falling down in walking has highest odds rate compared with other exercises. Given this background, the Nordic walking is increasing in Japan, because it is comparatively safe and has higher exercise intensity than walking. In fact, a lot of studies of many medical and health journals in Japan have reported that Nordic Walking is good for health.[2] Aging is becoming an important concern all over the world, and hence, we should reinforce strength, flexibility, and coordination abilities.

But the intensity of Nordic Walking might not be enough to improve respiratory muscles. Some new sports that are simplified and enjoyable for everyone should be proposed for all the people of the society irrespective of their age. Recently, there are a lot of studies that confirm that trunk muscle strength or trunk muscle stabilization training have effect on fall prevention in senior citizens.[3-5] Additionally, deep abdominal muscle strengthening, such as transverse abdominal muscle, contribute to respiratory function and lumbar stability.[6] Keeping and enhancing the trunk muscle strength would provide healthy life for senior people. Therefore, Blow Rifle was invented (http://www.blowrifle.com/html/index.php) in Japan keeping in concern the health of senior citizens. Blow Rifle is similar to blowgun, except the dart which isn't used during shooting. Blow Rifle uses the special ball (Blow ball) that is designed to spin around its axis of symmetry like a rifle bullet (Figure 1). The ball is loaded in the pipe (Blowpipe), which is 600 or 1200 mm in length, the players blow it towards the target *via* abdominal respiration as strongly as possible. The players exhale the air from their lungs while blowing out the ball. Blow Rifle could become a good sport which will be fun for everyone. From the young to the elderly, a lot of people in Japan have begun to play and enjoy this sport (Figure 2). Therefore, we present this case report about Blow Rifle with their effects on Electromyography (EMG) of the forced expiratory muscles during performing the Blow Rifle.

METHODS

Subjects: Five-healthy-males participated in this study (age=21.4±0.9 yr, weight=66.8±6.0 kg, height=171.0±6.6 cm). They regularly undertook exercises, such as basketball, soccer or volleyball, three times per week. They were also familiar with the experimental procedures and the activity of Blow Rifle. Before participation, all participants provided written informed consent. This study was approved by Human Ethics Review Committee of Shizuoka University, Shizuoka, Japan.

SPORTS AND EXERCISE MEDICINE

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Figure 1: The Equipment to Enjoy Blow Rifle.

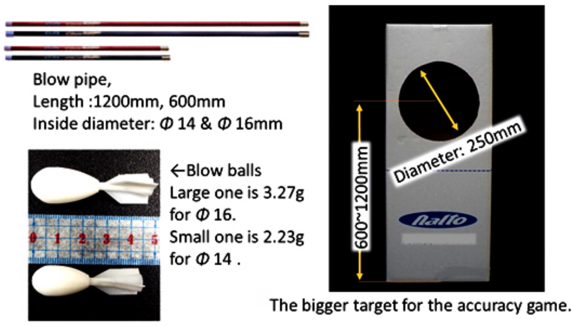


Figure 2: Blow Rifle. Left picture is Accuracy and right is Distance.

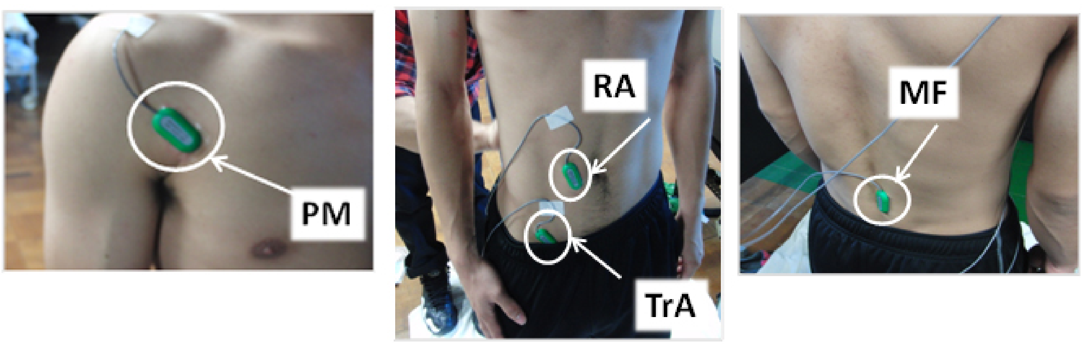
Experimental Design

Participants arrived at the laboratory at least 30 min before the experiment where surface EMG electrodes were attached to the experimental muscles and warmed up for the blowing exercise. The electrodes section attached are shown in Figure 3. Then each participant blew the blow balls by using the blow pipe mounted with a strain gauge on the muzzle side of pipe and spirometer (Chestgraph HI101, Chest, Japan) with a thermistor on mouth piece side (Figure 4). Following a warm-up, participants completed 2-3 maximal effort trials, while the blowpipe was kept in the horizontal position.

Data Collection

EMG data of greater pectoral muscle (PM), rectus abdominal (RA), Transverse abdominal (TrA), and multifidus muscle of L5 (MF) were collected during blowing (Figure 3). The EMG electrodes were placed over the inferior regions for TrA[7] and 2 cm lateral to the spinous process for multifidus muscles.[8] Surface EMG activities of the other accessory respiratory muscles, PM and RA, were recorded from the belly of each muscle with preamplifier mounted electrode (EMG Isolator SX230; Biometrics, UK). The skin on each belly was wiped with ethanol, followed by clean cream (Skin Pure; Nihonkoden, Japan), to lower the resistance of the skin between electrodes <10 kΩ. A strain gauge and thermistor were attached on the each end of the blowing pipe to calculate the physical parameters, the time of peak flow and launched blow ball from the pipe after blowing the ball. The analog signals of the EMG, strain gauge and thermistor were simultaneously sampled with an A/D converter (Power Lab 16/35, AD Instruments, New Zealand) at 1 kHz and were stored on a PC. Collected data were analyzed with AD Instruments' Lab Chart Pro software. The activity of each muscle was showed as a

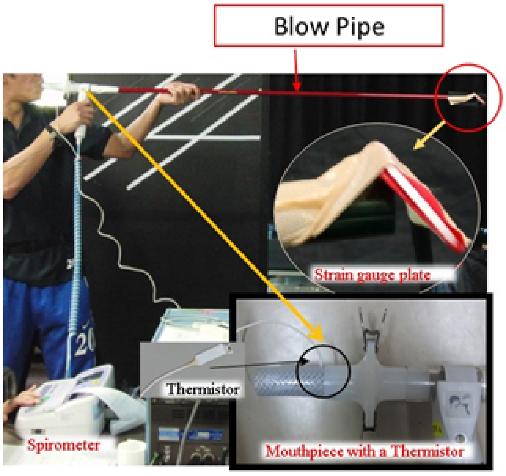
Figure 3: The Attached Surface EMG Sensor on each Accessory Respiratory Muscle. the data was Synchronized and Collected with Thermistor and Strain Gage Data which Attached on the Edge of Blowing Pipe in 1 kHz Frequency Sampling.



ISSN 2379-6375

http://dx.doi.org/10.17140/SEMOJ-3-148

Figure 4: A Picture of Experiment. Each Subject used this Pipe to Blow the Ball. This Pipe was Mounted Strain Gauge Plate on the Muzzle side of Pipe and Spirometer Mouthpiece on the Mouth Side.



%MVC. %MVC during blowing was averaged for 0.3 sec from blowing.

RESULTS AND DISCUSSION

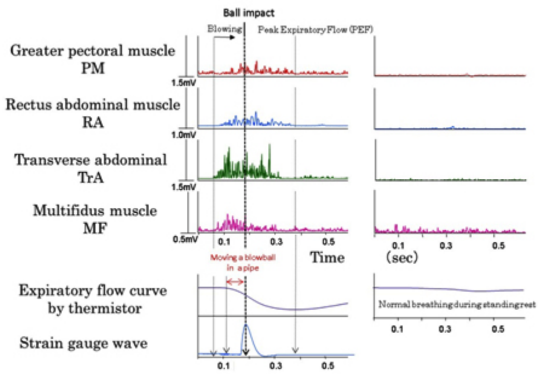
By inhaling deep fresh air and exhaling instantaneously and strongly by blowing, we have discussed about the results of EMG patterns on blowing of Blow Rifle games. The subjects blew the blow balls loaded in the pipe mounted with a thermistor and disposable mouthpiece of the spirometer. Addition to, the plate of strain gauge was mounted on the muzzle of blow pipe.

The activity of each accessory respiratory muscle during blow is shown in Figure 5. The electronic activity of each muscle is amplified between a beginning and after 0.3 sec of blow. PM, RA, TrA and MF increased immediately after the beginning of blow, comparing the EMG pattern of normal expiration during standing rest. This phenomenon was observed in all subjects. Especially, %MVC of TrA is 28.3±15.3 (Table 1). It is illustrated that blowing the blow ball would make more active deep small muscles. Trunk muscle strength is important for balance, functional performance, and fall prevention in seniors.[3] TrA and MF are one of them, and their important roles are also reported by the previous study.[6,9,10] Kim and Lee[6] reported that both FVC and FEV1 significantly increase after transverse muscle strengthening training, comparing with control group. It is suggested that enjoying Blow Rifle would be effective on trunk muscles.

However, there were few limitations of this study as: firstly, the subjects were young healthy males, not senior citizens; secondly, the number of subjects of this study were too less to provide the results through statistical analysis. These residual problems would be resolved in future studies.

Lastly, improving respiratory and trunk muscles will be expected to postural correction or prevent deteriorated posture or falling. International Blow Rifle Association has introduced three competitive games, Accuracy, Distance and Combined (Figure 6). When combined, it is performed with walking, run-

Figure 5: EMG of Accessory Respiratory Muscles during Blowing the Ball (Left). all Subjects have Similar EMG Pattern, Expiratory Flow Carve and the Wave of Strain Gauge Mounted the Top of Pipe. Right Pattern shows EMG for Normal Breathing During Standing Rest.



ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-148

Table 1: Averaged %MVC of each Muscle During Blowing the Blowball.

	PM	RA	TrA	MF
Mean	6.6	3.1	28.3	3.9
SD	3.4	1.2	15.3	1.2

Figure 6: Combined Blow Rifle game. The Example of Combined Game, Noridic Walking and Brow Rifle. The Participants Walk a given Distance with Nordic Walking and Blow the 5 Blowballs by 2 or 3 Blowing Rounds. Depending on the Blowing Performance, Extra Distance or Time is Added to the Participant's Total Running Distance/Time.

ning or other sports, such as Biathlon of winter sports. The combination of these sports would provide various good effects on health and hence enhance QOL. Considering that the respiration is an important fundamental function for our long life, this new sports would be one of the most useful sports which will support the health of aging society. Including Blow Rifle activities with the walking among senior people would improve respiratory muscle strength and trunk strength which may help in prevent falls for which further research in the elderly population is necessary.

CONSENT

Consent has been taken from the patient's for purpose of using patient's photographs for publication in print or on the internet.

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ISSN 2379-6375 Open Journal http://dx.doi.org/10.17140/SEMOJ-3-149

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Volume 3 : Issue 2
Article Ref. #: 1000SEMOJ3149

Article History
Received: March 15th, 2017
Accepted: June 20th, 2017
Published: June 22nd, 2017

Citation
Mills C, De Ste Croix MS, James D. Linearity of the scale for mass and volume within the air displacement plethysmograph (BOD POD): A methodological investigation. *Sport Exerc Med Open J*. 2017; 3(2): 58-62. doi: 10.17140/SEMOJ-3-149

Linearity of the Scale for Mass and Volume within the Air Displacement Plethysmograph (BOD POD): A Methodological Investigation

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ABSTRACT

Introduction: In order to maintain the accuracy and reliability for both volume and mass measurements of the air displacement plethysmograph (BOD POD) on a day-to-day basis, quality assurance processes are undertaken. Given the importance of accurate estimation of body mass and body volume in determining body composition, the aim of this methodological investigation was to further examine the calibration approaches and to independently determine both the linearity and reliability of mass and volume measurements throughout the potential measurement range.
Methods: Routine calibration procedures for mass (sequentially add known masses ranging from 10-30 kg) range and volume (sequentially add known volume of balloons ranging from 49.900 L to 118.40 L) were conducted using BOD POD model 2000A (Life Measurement Inc. (LMI), Concord, CA, USA). Scatter plots between actual (known) against predicted (measurement) mass and volume values and bias and 95% limits of agreement plots were produced to illustrate the agreement, and paired *t*-tests to determine significant differences between the volumes.
Results: Results revealed that for all mass measurements between 10-30 kg the known mass and measured mass were in agreement. With respect to all volume measurements, the predicted (measured) volume differed from the actual (known) volume by as little as 0.2 L and as much as 0.9 L. There was a difference between actual (known) (mean±SD=65.1±35.9 l) and predicted (measured) (64.7±35.8 L), t_9=6.35 p<0.01.
Conclusion: One might question the relevance of only being able to calibrate mass to a maximum of 30 kg, when body mass of adult participants certainly exceed 30 kg. Results from the adapted volume calibration trial using balloons revealed underreporting of predicted (measured) volumes by 0.4 L. However, on the basis of this methodological investigation, it is possible to be broadly confident with the linearity and reliability of both mass and volume measurement outcomes from the BOD POD involving a reasonable level of rigour.

KEY WORDS: Air displacement plethysmograph; BOD POD; Linearity; Method; Mass; Volume; Reliability.

INTRODUCTION

The air displacement plethysmograph or its trade name BOD POD® (BOD POD) which is more familiarly known uses the inverse relationship between pressure (P) and volume (V) to derive body volume of a participant from a 750 L fibreglass shell that comprises of two chambers.[1] Firstly, the test chamber that accommodates the participant during testing and secondly, the reference chamber that contains instrumentation for measuring changes in pressure between the two chambers.[2-4] The moulded front seat forms a common wall separating the test and reference chambers, each with an approximate volume of ≈450 and 300 L respectively with a vol-

ISSN 2379-6375

http://dx.doi.org/10.17140/SEMOJ-3-149

ume-perturbing element (a moving diaphragm) connecting the two chambers[5] as shown in Figure 1. The volume of a participant body is measured indirectly through the application of relevant physical laws (Boyle's Law) by subtracting the volume of air it displaces inside an enclosed chamber when the participant is inside, from the volume of air in the chamber when it is empty.[4,6-8]

With the procedural difficulties associated with hydrostatic weighing, the introduction of air displacement plethysmography in 1995 gained popularity among body composition researchers.[3,8,10] This is mainly attributable to the BOD POD offering several viable operating alternatives to hydrostatic weighing.[11,12] For instance, by replacing the intimidating inconvenience of water immersion (~30 minutes) with the comfort of air (~5 minutes), can place fewer demands on the participant.[3,5,14] As a result, there is potentially a wider clinical application including athletes, children, obese, older adults and people with disabilities.[8,14,15] However, since its development, researchers have reported varying degrees of reliability and validity issues.[16] For instance, Collins et al[17] reported reliability values of 0.994 and a technical error of measurement of 0.448% and discovered that BOD POD whole body density measurements (1.064±0.002 $g.ml^{-1}$) were significantly greater ($p<0.05$) than hydrostatic weighing whole body density (1.060±0.002 $g.ml^{-1}$), concluding that that the BOD POD was over predicting whole body density.[17] Interestingly, Lockner et al[18] found there was a significant difference between average BOD POD whole body density (1.0466±0.0187 $g.ml^{-1}$) and average hydrostatic weighing whole body density (1.0403±0.0187 $g.ml^{-1}$) ($p<0.0005$). From a practical point of view, there have been even been reports that obese participants and large athletes on occasion have struggled to sit inside and close the BOD POD.

As part of the quality assurance process, the BOD POD was rigorously tested by the manufacturers, Life Measurement Inc. (LMI), Concord, CA, USA, to establish accuracy, reliability and linearity for both volume and mass measurements.[2,9] These quality assurance processes are undertaken by the manufacturer before to distribution and installation of the BOD POD, where multiple tests of 20 kg, 40 kg, 60 kg and 80 kg masses and 30 L, 50 L and 90 L volumes are conducted.[9] However, in order to maintain the accuracy of the BOD POD on a day-to-day basis, further quality control procedures are required *in situ*.[9] These quality control procedures consist of a mass and volume calibration which are conducted before every testing bout and are designed to check the linearity and reliability of the BOD POD system.[9] These calibration techniques were executed following the manufacturer's automated process by inputting measured values *via* the user interface. The procedure required the primary investigator to perform sequential steps without interruptions with equipment provided by LMI, Concord, CA, USA.[18]

METHODS

Calibration measurement protocols for both mass and volume were rigorously followed in accordance with the step by step instructions given on the BOD POD (BOD POD model 2000A, LMI, Concord, CA, USA) system computer. This procedure required the researcher to perform five sequential calibration attempts without interruptions for both mass and volume.

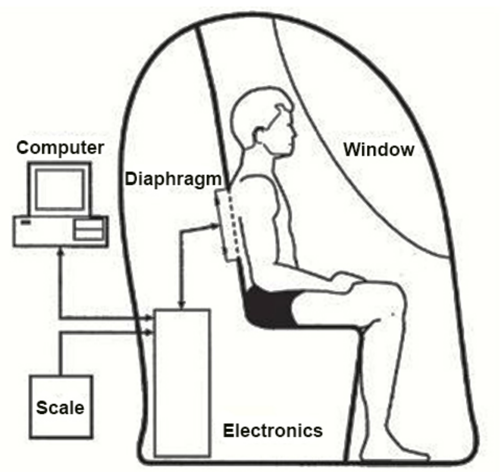
Measurement Procedure for Mass

The routine mass calibration procedure was followed and the researcher was able to sequentially add known (actual) calibration masses ranging between 10 kg to 30 kg. Although not ideal, given the likely range of measurements in practice, the relationship between actual and predicted mass could be plotted (0-30 kg) and extrapolated linearly to likely measurement values within a realistic range.

Measurement Procedure for Volume

Following the routine volume calibration procedure where calibration is repeated if two of the five mean volume measures are not between 49.900 L and 50.100 L.[9] The researcher was able to

Figure 1: General Arrangement of Chambers, Participants and Diaphragm. (Life Measurement Inc.,)[9]



ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-149

sequentially add up to ten known (actual) volumes corresponding to 118.40 L (i.e., 11.84 L, 23.68 L, 35.52 L, 47.36 L, 59.20 L, 71.04 L, 82.88 L, 94.72 L, 106.56 L and 118.40 L). The known volumes were established using balloons that were each inflated with 12 L of air using a Morgan Medical 3 L calibration syringe (Ferrari's Cardio Respiratory Ref 0413, Morgan Medical Ltd., Rainham, Kent, England) (i.e., 4x3 L=12 L volume of air into each balloon). Unfortunately due to the practicalities of the inflation procedures, releasing of the syringe and tying of each balloon resulted in χ 0.16 L of air being lost. Each balloon was verified as having a known volume of 11.84 l through the normal BOD POD calibration process of 5 volume measurements in succession.

Data analysis included a scatter plot of actual (known) against predicted (measured) mass values was produced to illustrate the agreement between the predicted mass and actual mass measures and extrapolated between 40 to 120 kg (Figure 2). Figure 3 illustrates the agreement between the actual (known) against predicted (Manufacturer's calibration equipment included two 10 kg calibration National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA weights that are used on the digital weighing scale to calibrate mass and a 50.110 L calibration cylinder that is used within the BOD POD chamber to calibrate volume). Given the central importance of accurate estimation of body mass and body volume in determining body composition, the aim of this methodological investigation it is crucial to independently review both the linearity and reliability of mass and volume measurements for the BOD POD and to further examine the calibration approaches throughout the potential measurement range (measured) volume values and the linearity through the likely (practical) measurement range. The bias and 95% limits of agreement between the actual (known) against the predicted (measured) volumes are illustrated in Figure 4. Paired *t*-tests were undertaken to determine whether significant differences were present between the known and measured volumes.

Figure 2: Actual (known) *versus* Predicted (measured) Mass and Extrapolation for the BodPod through the Likely Measurement Range.
Note: Extrapolated from 40.00-120.00 kg.

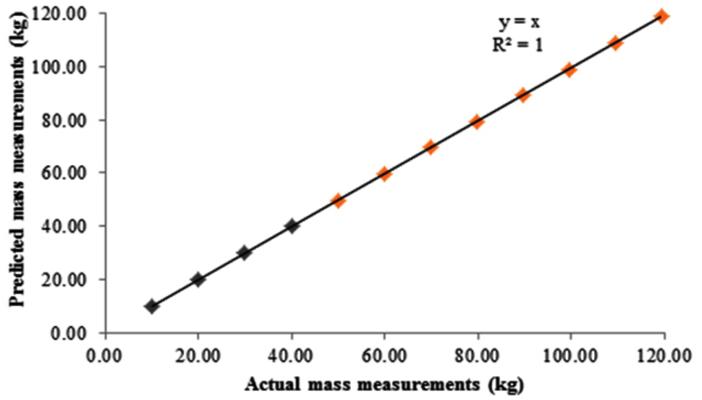
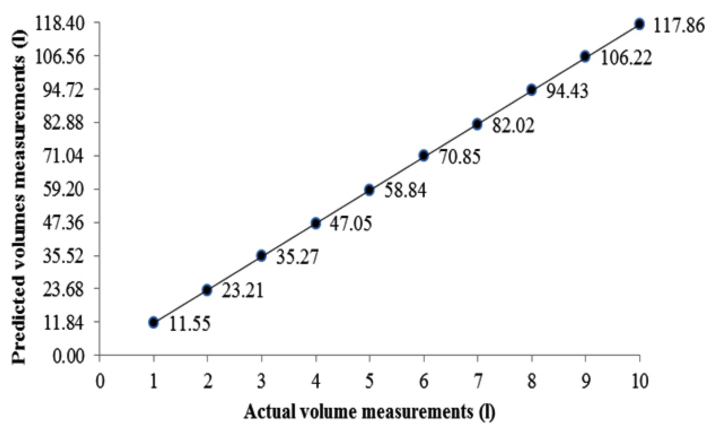
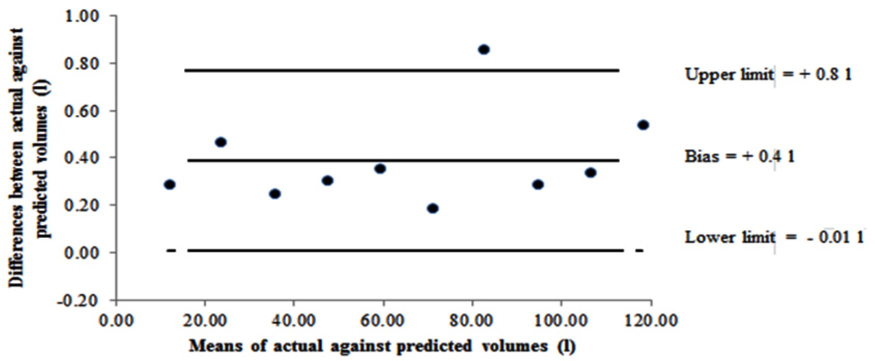


Figure 3: Actual (known) and Predicted (Measured) Volumes from the BodPod through the Likely Measurement Range.



ISSN 2379-6375 http://dx.doi.org/10.17140/SEMOJ-3-149

Figure 4: Bland and Altman Plot Showing Bias and 95% Limits of Agreement between the Actual (known) Against the Predicted (Measured) Volume for BodPod.
Note: A positive bias indicates higher actual (known) values in relation to the predicted (measured) values.



RESULTS

Results revealed that for all mass measurements between 10-30 kg the known mass and measured mass were in agreement (Figure 2). Furthermore, measures of mass between 40-120 kg extrapolated (Figure 3) to estimate the value of masses outside the range tested.

Results revealed that for all volume measurements, the predicted (measured) volume differed from the actual (known) volume by as little as 0.2 L and as much as 0.9 L (Figure 3). When comparing the agreement between the actual (known) volumes against the predicted (measured) volumes, results indicated systematic bias whereby the predicted (measured) volumes were underreported compared with the actual (known) volumes (Figure 4). There was a difference between actual (known) (mean±SD=65.1±35.9 L) and predicted (measured) (64.7±35.8 L), t_9=6.35 p<0.01.

CONCLUSION

With regards to mass, the calibration masses from 10-30 kg were in agreement and in line with the BOD POD system quality control process when checking mass linearity and reliability.[9] However, one might question the relevance of only being able to calibrate a measurement tool to a maximum of 30 kg, especially when the body mass of participant's are certainly in excess of 30 kg. As LMI, Concord, CA, USA, calibration equipment consists of two 10 kg calibration NIST weights for the calibration process on the digital weighing scale, this does pose the question whether the BOD POD system is designed to provide operator ease when lifting relatively light weights repeatedly or whether it checks the linearity across the mass scale. Similarly the reliability and linearity of the volume scale was measured within the BOD POD system at 30 L, 50 L and 90 L. Results from the adapted volume calibration trial using balloons revealed underreporting of predicted (measured) volumes by 0.4 L, which slightly exceeds the LMI, Concord, CA, USA, recommended calibration range between 0.01-0.21 L.[9] Given the importance of accurate estimation of body volume in determining body composition, it is questionable why LMI, Concord, CA, USA only provide a 50.110 L calibration cylinder and again poses the question of operator ease *versus* linearity. It is unfortunate that there is no facility to independently test the BOD POD for the linearity of the mass and volume scale, therefore conducting quality control procedures throughout the potential measurement range (in relation to the population sample) is something that should be taken into account in future research. On the basis of this methodological investigation however, it is possible to be broadly confident with the linearity and reliability of mass and volume measurement outcomes throughout the measurement range from the BOD POD involving a reasonable level of rigour.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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