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Abstract

The purpose of this study was to determine the impact of participating in small (3v3), medium (6v6), and large-sided (12v12) games on the physical activity levels (pedometer step counts, accelerometer counts, and minutes of moderate-to-vigorous physical activity) and ball touches of children in physical education class. Participants were 29 students (55% boys and 45% girls) age 10-11 yrs. All participants wore a Yamax SW-200 pedometer and had their ball touches monitored and recorded. Twelve participants also wore an ActiGraph GT3X accelerometer. Repeated measure ANOVAs were computed to test for significant differences for each dependant variable with corresponding post hoc tests. Results indicated the 3v3 and 6v6 game conditions yielded significantly higher accelerometer counts and ball touches than the 12v12 condition. The 3v3 game condition also produced significantly higher ball touches than the 6v6 condition. These findings highlight the importance of utilizing smaller-sided games in physical education to promote increased involvement and physical activity.

Keywords: physical activity, game size, skill development

Introduction

In an age where childhood obesity and sedentary behaviors are increasingly abundant, physical education continues to be viewed as an opportunity for children to obtain physical activity and develop motor and/or activity skills (National Association of Sport and Physical Education [NASPE], 2004, 2008). Game play is a fundamental component of physical education lessons that can help students accumulate physical activity and foster skill acquisition. Game play has the potential, however, to reduce the likelihood that some children will obtain adequate levels of physical activity and acquire or develop motor skill competencies. For this reason, research has explored the impact of game size (e.g., 3v3, 6v6, 11v11) on physical activity levels and ball or object of manipulation touches of students in physical education class (Arnett & Lutz, 2003; Kern & Calleja, 2008).

The National Association for Sport and Physical Education (NASPE) recommends using small sided games to maximize learning and physical activity engagement at all levels in the *Appropriate Instructional Practice Guidelines* (NASPE, 2009). Physical education curricula that have included small-sided game-based activities (3v3, 2v2, or 1v1) have been shown to increase the likelihood that middle school girls, regardless of skill ability level, engage in moderate-to-vigorous physical activity (MVPA) for greater than 50% of class time (Arnett & Lutz, 2003). In another study, Arnett (2004) found that small-sided soccer games (i.e., 3v3 or less) significantly increased the likelihood that college-aged participants obtained MVPA compared to middle- (5v5) or large-sided soccer games (11v11). Furthermore, Kern and Calleja (2008) observed that middle- and large-sided games typically end up being like small-sided games because only the highly skilled participants stay actively involved. The persistent theme across each of these studies is that small-sided games result in increased physical activity compared to middle- and large-sided games.

The number of times a student touches the object of manipulation during game play likely influences the amount of skill acquisition or development that occurs. Designing game play activities that keep *all* students involved is of paramount importance. Kern & Calleja (2008) found that the number of ball touches among middle school students ranged from 14 to 33 during small-sided (3v3) soccer games lasting 14 minutes each. During middle- and large-sided games of similar durations, the number of ball touches ranged from 0 to 27 highlighting that some students never touched the ball. The importance of utilizing small-sided games, in this case, to promote active engagement and skill development is observed.

The question as to whether small-sided games (compared to middle- or large-sided games) results in increased physical activity and level of engagement (i.e., ball touches) amongst elementary-aged children during physical education class remains unanswered. Therefore, the purposes of this study were to (a) determine the effects of participating in small- (3v3), medium- (6v6), and large-sided (12v12) throwing and catching games on the physical activity (i.e., pedometer step counts, accelerometer counts, and MVPA) and actual ball touches of 10-11 year-old elementary school children in physical education class and (b) examine the effects of gender on pedometer step counts and ball touches by game condition.

Methods

Participants

The participants of this study were 29 students (13 girls, 16 boys) age 10-11 years (M = 10.93, SD = .258) from one intact physical education class. The children attended an elementary school located in a middle-to-upper class neighborhood in a small metropolitan area of the northwest United States. The particular class chosen for this study was selected because a variety of skill ability levels were represented. To ensure homogeneity of teams, each team in each game condition consisted of an equal number of high, medium, and low skilled participants. High, medium, and low skilled participants were categorized by the physical education teacher who has 12 years of teaching experience. The framework for skill level classification was derived from Graham's (2010) Generic Levels of Skill Proficiency (GLSP) specifically relating to throwing, catching, and moving to open spaces.

Institutional review board (IRB) approval and school principal and physical education instructor permission was granted prior to introducing participants to the study. After being informed about the expectations of the study, each potential participant was given informed consent for review and signature by a parent/guardian. Only participants who returned signed informed consent were allowed to participate.

Instruments

All participants wore a single function Yamax SW-200 pedometer and twelve randomly selected participants also wore an ActiGraph GT3X accelerometer, which measures physical activity in three axes. Both motion sensors have demonstrated appropriate levels of validity and reliability in field settings with children (Beighle, Morgan, Le Masurier, & Pangrazi, 2006; Freedson, Pober, & Janz, 2005; Schneider, Crouter, & Bassett, 2004). A 60-second epoch or time sampling interval was employed for the accelerometers. Six adults (three university PETE faculty, the school PE instructor, and two graduate research assistants) were employed to record the number of ball touches each participant accumulated during the three game conditions. A ball touch was defined as any time a study participant made contact with the ball whether it was caught, dropped or intercepted. For identification purposes, each participant was assigned a number and wore that number on the front and back of a pinnie. Each time a participant touched the ball a researcher would record their number.

Procedures

Three researchers provided a 20-minute motion sensor orientation that instructed participants on proper placement and usage of the devices. Participants were instructed to wear the motion sensor(s) above the right knee on the waist band of their pants or shorts. A short movement-oriented learning activity was employed to further familiarize participants with the function of the devices. Each participant was randomly assigned a numbered motion sensor(s) to wear throughout the study.

A throwing and catching game was chosen for this study because it incorporated two skill themes (throwing and catching) and one movement concept (GLSP, "moving to open spaces") typically used in a variety of activities children engage in during physical education class. The equipment and rules for the throwing and catching game were as follows:

- 8-inch gator skin balls
- Cones marking all play areas on grass fields
- Stop watch to time each game and the transition time between games
- A point was scored by completing five consecutive passes with teammates
- Teammates could not continuously pass back and forth with a single partner
- Turnovers occurred when a ball was dropped, thrown out of bounds, or intercepted by the other team
- All games started and ended at the same time

These rules were implemented in all game size conditions. The three game size conditions utilized in this study were small- (3v3), medium- (6v6), and large-sided (12v12) and were administered in that order on three separate days during regularly scheduled physical education classes. Game play was limited to 12 minutes for each condition. A round robin format was utilized where six 2-minute games were played with a minute for rest and team rotation in between games. Playing area size was 10x10 yards for the 3v3 condition, 20x20 yards for the 6v6 condition and 40x40 yards for the 12v12 condition to standardize the amount of playing space utilized per player.

During the 3v3 and 6v6 game conditions, seven additional non-study participants were included from another 5th grade class. The 12v12 game condition required an additional 19 non-study participants. Non-study participants from one other physical education class were selected by utilizing the GLSP protocol to ensure consistency on all teams and so that all study participants were engaged during the same time period (no waiting for a team to play).

At the beginning of each physical education lesson, the physical education instructor invited participants to attach one or both motion sensors to the waistband of their pants or shorts; an instant activity was then administered to prepare participants for game play. Immediately prior to beginning game play, the instructor invited students to reset their pedometers. A whistle blow would then initiate game play and prompt a researcher to start the timer. Each participant's ball touches during each game-size condition were monitored and recorded by research team members. At the end of each 2-minute game a whistle blow would stop play and teams would be instructed to rotate to play a new team. One minute was allowed for rest and rotation and to ready teams for the next game. Fields were adjacent to each other to minimize the amount of ambulatory activity accumulated during the transition period. The procedure would repeat until 12 minutes of game play had been completed (six separate games). At the end of 12 minutes of game play study participants were instructed to remove their pedometers and accelerometers. Research team members would then record pedometer and accelerometer readings for each day.

Design and Data Analyses

This was a repeated measure design with three game size conditions (3v3, 6v6, and 12v12). Descriptive statistics (means, standard deviations) were calculated for pedometer step counts, accelerometer counts, minutes of MVPA, and ball touches overall and by gender. The accelerometer cutpoint for moderate or greater intensity physical activity was 2059 (>4 METs) and was derived from Freedson et al. (2005) age-specific prediction equation. Due to student absentism, motion sensor malfunction, or a limited number of accelerometers, the N for each dependant variable was reduced and/or different. For this reason, four separate repeated measure ANOVAs (one for each dependent variable) were computed to test for significant differences between the three game size conditions with corresponding post hoc tests using a Bonferroni adjustment. Significance was established at $p \leq 0.0125$ by dividing .05 by four (the four dependent variables) to guard against making a Type I error. Six one-way ANOVAs were also computed to test for significant differences in pedometer step counts and ball touches by gender across each game condition. Significance for the one-way ANOVA tests was established *a priori* at $p \leq 0.05$. All statistical analyses were calculated using SPSS version 19.0 (SPSS, Inc., Chicago, IL.).

Results

Descriptive statistics (means and standard deviations) are presented in Tables 1 (overall) and 2 (by gender). Sphericity was assumed for pedometer step counts and ball touches but not for accelerometer counts or minutes of MVPA. In the latter two cases, the Greenhouse-Geisser adjustment was employed. Results of the repeated measure ANOVA tests indicated treatment effects for pedometer step counts ($F(2, 50) = 8.787$; $p < .01$; $\eta = .26$), accelerometer counts ($F(2, 12.35) = 9.922$; $p < .01$; $\eta = .50$), and ball touches ($F(2, 52) = 84.575$; $p < .001$; $\eta = .76$). Post hoc tests revealed that participants (a) accumulated significantly less pedometer step counts in the 3v3 than the 6v6 ($p < .001$) or 12v12 ($p < .05$) game conditions, (b) accrued significantly more accelerometer counts in the 3v3 and 6v6 than the 12v12 condition ($p < .05$), (c) obtained significantly more ball touches during the 3v3 than the 6v6 or 12v12 game conditions ($p < .001$), and (d) obtained significantly more ball touches during the 6v6 than the 12v12 game condition ($p < .01$). Results of the one-way ANOVA tests indicated boys accumulated significantly more pedometer step counts than girls in both the 6v6 ($F(1, 26) = 4.874$; $p < .05$) and 12v12 ($F(1, 26) = 8.436$; $p < .01$) game conditions.

Discussion

This study examined the physical activity levels and ball touches of children participating in small- to large-sided games during elementary physical education. The major findings indicated (a) participants accumulated significantly more accelerometer counts and ball touches in the 3v3 and 6v6 than the 12v12 game condition, (b) participants obtained significantly more pedometer step counts in the 6v6 and 12v12 than the 3v3 game condition, and (c) boys accrued significantly more pedometer step counts than girls in the 6v6 and 12v12 conditions but not the 3v3 condition.

Data from this study support other investigations that have focused on the effects of playing in small-sided games. While a majority of studies in this area have examined the game of soccer with elite athletes or skilled players, the general outcomes are similar to the current study. For example, when addressing engagement in small-sided games, elite boy soccer players had more individual ball contacts and overall game involvement when player numbers were decreased (Jones & Drust, 2007). Similarly, 11 year-old soccer players had significantly more passes when playing 7v7 than 11v11 (Capranica, Tessitore, Guidetti, & Figura, 2001). This increase in ball touches indicated that children had greater opportunities to be in possession of the ball to work on improving their skills. Katis & Kellis (2009) reported related findings when looking at soccer games of 3v3 and 6v6 with 13 year olds. These young adolescents had significantly more opportunities for technical improvement when playing games of 3v3. They had accumulated higher numbers of passes, kicks, dribbles, and shots on goal compared to playing in the larger-sided game. Overall, Katis and Kellis noted that smaller-sided games (i.e., 3v3) allowed better stimulus for technical improvement. Associated findings have also been reported with adults. Adult soccer players who played in games with fewer players, such as games of 3v3 and 4v4, had more changes in activity (i.e., standing, walking, jogging, sprinting) and had more performance opportunities (i.e., number of tackles, headers, shots, and turns) compared to playing in larger-sided games of 7v7 (Randers et al., 2010).

More opportunities to become engaged in a game often translate into higher participation levels, which may affect higher intensity levels. While various studies have examined heart rate intensity as it relates to playing smaller-sided games (Capranica, Tessitore, Guidetti, & Figura, 2001; Foster, Twist, Lamb, & Nicholas, 2010; Jones and Darst, 2007; Katis & Kellis, 2009; Rampinini, et al., 2007; Randers et al., 2010), the current study addressed changes in physical activity levels using pedometers and accelerometers. Interestingly, children in this study participating in larger-sided games (6v6 and 12v12) accumulated higher step counts than playing in the smaller-sided game (3v3). This result, in part, was due to the increase in field dimensions to accommodate larger numbers of players. It is plausible that children had to move around more often within the extended playing areas and larger team sizes to get open to receive a pass, accounting for the higher step counts.

One would reason that increasing pedometer steps would also translate to higher physical activity levels. This assumption was not, however, the case in this study. Based on accelerometer analyses, when children played in smaller-sided games (3v3 and 6v6), they recorded higher levels of physical activity (i.e., accelerometer counts) than when playing in the large-sided game. One possible reason for this result could be due to the decrease in space that was used to play the smaller-sided games. It may be that there was a greater need for students to assume more of a player-to-player strategy in the smaller-sided games, thus affecting the intensity of their movements (Tessitore, Meeusen, Piacentini, Demaire, & Capranica, 2006). Higher physical activity levels could have been due to the mere fact that students had more ball possessions when playing in smaller-sided games, which ultimately created more

opportunities for involvement in the game (Jones & Drust, 2007; Rampinini, et al., 2007). Perhaps the most likely reason for the higher accelerometer counts with smaller-sided games was the result of quick spurts of energy students used to find a space to get open for a pass. Similar reports by Foster et al. (2010) noted that elite junior rugby players appeared to increase their heart rate intensities in smaller-sided games (4v4) due to the small amount of anaerobic bursts of movements that supported game play. Participants in this study also appeared to make more sudden, sharp, and quick movements when playing in smaller-sided games confined to smaller spaces. While students may have accumulated higher step counts in the 6v6 and 12v12 games, their movements were not near as intense compared to playing in games of 3v3 or 6v6. Whether or not greater accelerometer counts translate into higher levels of MVPA for children in this study can only be conjectured. A previous study, however, did find higher percentages of MVPA levels when college-aged participants played small-sided soccer games (Arnett, 2004).

Gender is a well known correlate of physical activity (Van der Horst, Paw, Twisk, & Van Mechelen, 2007). In this study, boys obtained significantly higher step counts than girls in the 6v6 and 12v12 conditions but not the 3v3 condition highlighting the importance of utilizing small-sided games to allow girls equal opportunities for physical activity participation.

This study contained a considerable limitation: the number of participants who wore accelerometers ($N = 11$) during the intervention was low. A larger N would have likely shown significant differences between game size conditions in minutes of MVPA. It is important to note that even with the low N, the difference in minutes of MVPA among the three game size condition was extremely close to significance ($p = .044$).

Overall, the results of this study support the importance of using smaller-sided games in elementary physical education to enhance higher levels of skill engagement and physical activity. Developing skills and game-play tactics are objectives of most physical education programs. Students need the opportunity to be actively involved and learn, and utilizing smaller-sides games can help provide students with more occasions to improve their skills. Additionally, increasing physical activity levels is most likely a product of engaging students in small-sided games. All in all, the results of this study suggest using smaller-sided games in elementary physical education because they provide more opportunities to handle the object of manipulation and obtain physical activity.

References

Arnet, M.G., and Lutz, R.B. (2003). Measurement of moderate to vigorous physical activity of middle school girls, using tritrac activity monitors during small-sided, game-based lessons. *Measurement in Physical Education and Exercise Science*, *7*, 149-159.

Arnet, M.G. (2004). Effect of team size in soccer on moderate to vigorous physical activity. *Physical Educator, 61*(3), 114-119.

Beighle, A., Morgan, C.F., Le Masurier, G., & Pangrazi, R.P. (2006). Children's physical activity during recess and outside of school. *Journal of School Health*, *76*, 516-520.

Capranica, L., Tessitore, A., Guidetti, L, and Figura, F. (2001). Heart rate and match analysis in pre-pubescent soccer players. *Journal of Sports Sciences, 19*(6), 379-384.

Foster, C.D., Twist, C. Lamb, K.L., and Nicholas, C.W. (2010). Heart rate responses to small-sided games among elite junior rugby league players. *Journal of Strength and Conditioning Research, 24*(4), 906-911.

Freedson, P., Pober, D., & Janz, K.F. (2005). Calibration of accelerometer output for children. *Medicine and Science in Sports and Exercise*, *37*, S523-S530.

Graham, G. Holt/Hale, S.A., & Parker, M. (2013). *Children moving: A reflective approach to teaching physical education* (9th ed.). New York: McGraw-Hill.

Jones, S. and Darst, B. (2007). Physiological and technical demands of 4 v 4 and 8 v 8 games in elite youth soccer players. *Kinesiology, 39* (2), 150-156.

Katis, A. and Kellis, E. (2009). Effects of small-sided games on physical conditioning and performance in young soccer players. *Journal of Sports Science and Medicine, 8*, 374-380.

Kern, J., & Calleja, P. (2008). Let's play three on three! *Journal of Physical Education, Recreation, and Dance, 79(6),* 31-34.

National Association for Sport and Physical Education. (2004). *Moving into the future—National standards for physical education* (2nd ed.). Reston, VA: Author.

National Association of Sport and Physical Education. (2008). PE Metrics: Assessing the national standards. Reston, VA: Author.

Rampinini, E., Impellizzeri, F.M., Castagna, C., ABT, G., Chamari, K, Sassi, A., and Marcora, S.M. (2007). Factors influencing physiological responses to small-sided soccer games. *Journal of Sports Sciences, 25*(6), 659-666.

Randers, M.B., Nybo, L., Petersen, J., Nielsen, J.J., Christiansen, L., Bendiksen, M., . . . Krustrup, P. (2010). Activity profile and physiological response to football training for untrained male and females, elderly and youngsters: influence of the number of players. *Scandinavian Journal of Medicine and Science in Sports, 20* (Suppl. 1), 14-23.

Schneider, P.L., Crouter, S.E., & Bassett, D.R. (2004). Pedometer measures of free-living physical activity: Comparison of 13 models. *Medicine and Science in Sports and Exercise*, *36*, 331-335.

Tessitore, A., Meeusen, R. Piacentini, M.F., Demarie, S, and Capranica, L. (2006). Physiolgical and technical aspects of "6-a-side" soccer drills. *Journal of Sports Medicine and Physical Fitness,* 46(1), 36-43.

Van der Horst K., Paw M., Twisk J., Van Mechelen W. (2007). A brief review of correlates of physical activity and sedentariness in youth. *Medicine in Science in Sports and Exercise, 39*, 1241-1250.

Table 1

Descriptive statistics for physical activity and ball touches by game condition

		3v3	**6v6**	**12v12**
	N	Mean ± SD	Mean ± SD	Mean ± SD
Pedometer Step Counts	26	1318 ± 189*	1445 ± 184	1432 ± 194
Accelerometer Counts	11	4124 ± 883	3747 ± 686	3114 ± 1028*
Minutes of MVPA	11	11.64 ± .67	11.45 ± 1.21	9.82 ± 2.86
Ball Touches	27	28.5 ± 10.2**	14.1 ± 6.7***	9.1 ± 5.0

*significantly different from other two groups at $p < .05$.
**significantly different from other two groups at $p < .001$.
***significantly different from 12v12 group at $p < .01$.

Table 2

Descriptive stats for pedometer step counts and ball touches by gender

	3v3		6v6		12v12	
	N	Mean ± SD	N	Mean ± SD	N	Mean ± SD
Ped Step Counts						
Girls	12	1282 ± 177	13	1374 ± 165*	12	1329 ± 124**
Boys	16	1370 ± 196	15	1515 ± 171	16	1513 ± 191
Ball Touches						
Girls	13	26.77 ± 10.05	13	12.23 ± 5.54	12	8.17 ± 3.07
Boys	16	29.0 ± 9.88	15	14.80 ± 7.62	16	9.13 ± 6.20

*$p < .05$. **$p < .01$.