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AN INVESTIGATION INTO MODERATE TO VIGOROUS AND VIGOROUS PHYSICAL ACTIVITY ACCRUAL DURING INVASION AND NET-WALL GAME-FOCUSED TACTICAL GAMES MODEL LESSONS

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Abstract:
Students in physical education (PE) classes traditionally do not meet national recommendations of 50% moderate to vigorous physical activity (MVPA) within lessons. Information regarding the accrual of vigorous physical activity (VPA) is also sparse. Recent evidence suggests that lessons delivered via the Tactical Games Model (TGM) can provide a context where students can achieve national MVPA recommendations and accrue significant amounts of VPA. However, evidence is limited on how the type of game (Frisbee/badminton) and/or game category (invasion/net-wall) may affect opportunities for students MVPA/VPA accrual. The purpose of this study was to investigate how MVPA/VPA varied as a function of game type/category when preservice physical education teachers PSPET's taught TGM lessons. Participants were PSPET's at one Mid-Western University (N=24) who learned to use TGM in one university-based course within their Physical Education Teacher Education (PETE) program. As part of the course, each PSPET taught one TGM lesson within invasion (lacrosse and Frisbee) and net/wall (badminton and pickleball) games. 24 lessons were delivered in total (n = 6 from each game). Lesson context and teacher behavior data were collected. PSPET's wore ActigraphGTX3® triaxial accelerometers to collect MVPA/VPA data. TGM fidelity was established (Metzler, 2011). Lesson context and teacher behavior data were analyzed descriptively. PA data were analyzed using repeated measures ANOVA. Lesson context data showed that teachers spent most of their time in game play, followed by skill practice. Results from accelerometry revealed

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that PSPET's did not reach national MVPA recommendations during any of the sessions focused on the different games types. VPA was also lower than recorded in previous studies. PSPET's accrued greater levels of MVPA/VPA in invasion games.

Keywords: physical activity; games; pedagogy; tactical games model

1. Introduction

Models-Based Practice (MBP) has been suggested as a means of overcoming limitations of traditional physical education (PE) curricula (Kirk, 2013), which has been chastised for being 'a mile wide and an inch deep'. Kirk's main justification for a move to MBP is due it its educational value, affirming the notion that PE has the potential to contribute to a wide range of beneficial outcomes across an array of domains. This contrasts with a traditional 'one-size fits all', physical-education-as-sports-techniques (Kirk, 2010), multi-activity curricula (Kirk, 2013). In this curriculum model students often practice in isolated, non-linear, decontextualized conditions that are unlikely to generalize to game conditions, spend much of their lesson time inactive (Kirk & MacDonald, 1998). In addition, the teachers' behavior and practice is characterized as highly directive and prescriptive in nature (Harvey, Cushion, & Massa-Gonzalez, 2010) and students and have little opportunity for empowerment and creativity (Butler & McCahan, 2005).

There is an emerging literature base on second generation models (cooperative learning, sport education, and the Tactical Games Model) underpinned by constructivist learning theory (Kirk & MacDonald, 1998). In Game-Centered Approaches (GCAs) such as the Tactical Games Model (TGM), the teacher utilizes a game-skill-game format to promote the links between tactics and technique with the aim of promoting skillful and intelligent performance (Kirk, 1983). For example, an initial game form is introduced first (i.e., a 3 vs. 3 game to one goal in lacrosse), with skill practice introduced second (i.e., creating passing lanes off-the-ball), before returning to the 3 vs. 3 game form. In the TGM, the *what* therefore comes before the *how*, refuting the notion that quality game play cannot emerge until the core techniques are mastered a priori (Oslin & Mitchell, 2006).

Research on GCAs (see Harvey & Jarrett, 2014 for an extended review) such as TGM provide evidence for the development of cognitive outcomes (i.e., tactical; Vande Broek, Boen, Claessens, Feys, & Ceux, 2011), affective outcomes (i.e., student motivation; Gray, Sproule, & Morgan, 2009) and psychomotor outcomes, particularly off-the-ball movement (Lee & Ward, 2009). However, more recently, a limited number of studies (Harvey et al., 2016a, b; Van Acker et al., 2010) have begun to provide evidence that teachers' use of a GCA can afford students opportunities to engage in moderate-vigorous physical activity (MVPA) for at least 50% of the lesson time, consistent with national recommendations (Association for Physical Education, AfPE, 2008; Institute of Medicine, IOM, 2013). Moreover, studies have demonstrated teachers' use of GCAs provide students with greater opportunities to accrue MVPA than lessons focused on direct instruction (Dania, Kossyva, & Zounhia, 2017; Harvey et al., 2015a; Miller et al., 2015, 2016; Smith et al., 2015; Yelling et al., 2000). This is particularly significant as it has been well documented that regular physical activity (PA) of at least a moderate intensity is related to an overall improvement in health and wellbeing along with a reduced risk of chronic diseases in children and young people (e.g., Andersen et al., 2006).

In addition, more recent studies (e.g., Harvey et al., 2015a; Smith et al., 2015) have shown that teachers use of a GCA can provide opportunities to engage in vigorous physical activity (VPA). For example, Harvey et al. (2015a) have reported VPA data demonstrating that a GCA-focused TGM unit of field hockey afforded students opportunities to accumulate VPA above and beyond that previously reported in the literature. The limitation of this study was its focus on only two middle school-aged classes, and therefore its low sample size. Nevertheless, this is significant given that national recommendations, both in the US and United Kingdom (UK), are emphasizing the importance of VPA on at least three days per week (Centers for Disease Control, CDC, 2008 Department of Health, DoH, 2011). Providing children with more opportunity to engage in VPA is of particular significance given its positive association with cardiorespiratory fitness (e.g., Denton et al., 2013), vascular function (e.g., Hopkins et al., 2009) and body fat (e.g., Ruiz et al., 2006).

This body of emerging research into PA in GCAs is therefore promising. However, most GCA studies that have focused on PA have been restricted to invasion games, and, consequently, we do not know the impact of a teachers' utilization of a GCA such as the TGM on students PA in games from different game categories such as net-wall games (i.e., badminton, pickelball), for example. Knowing the impact of GCA's such as TGM on PA levels in games from different categories could aid teachers in developing an appropriate scope and sequence for their curriculum, so that games where students accrue lower PA can be balanced alongside games which typically generate higher levels of PA, such as invasion games (Brusseau & Burns, 2016; Fairclough & Stratton, 2005, 2006). The utilization of Pre-Service Physical Education Teachers (PSPET's) in this current study, who have undertaken a specific course educating them about using GCAs such as the TGM, alongside using published TGM instructional materials, also provides context for making robust conclusions about the likely impact of TGM-focused lessons on student PA levels. Moreover, asking PSPET's to wear accelerometers during their participation in TGM-focused lessons also provides an objective measure of PA, so it can be contrasted with the results of previous or future studies. Third, given the growing focus in PA recommendations on the need to participate in VPA on three days of the week (CDC, 2008; DoH, 2011), greater attention can be afforded to research studies in reporting VPA data, particularly where the content chosen may result in significant accumulation of VPA.

This current study is therefore a timely addition to the growing literature base on PA within GCAs given its inclusion of data from PSPET's as they participated in multiple TGM lessons focused on two different categories of games (i.e., invasion, net-wall) and four different sport games (Frisbee, lacrosse, badminton, pickelball). Moreover, it additionally reports the contribution of MVPA/VPA. Consequently, the purpose of this study was to investigate the effects of TGM delivery on MVPA/VPA in these different game categories and sports.

2. Materials and Methods

2.1 Participants and Setting

Participants were PSPET's at one Mid-Western University (N=24) who learned to use TGM in one university-based course within their Physical Education Teacher Education (PETE) program. Specifically, they were enrolled in a curriculum and instruction class, which provided the PSPET's with an initial experience of learning about and teaching with the TGM.

Ethical approval for this study was granted by an Institutional Review Board (IRB) for the protection of human subjects at a large Mid-Western United States University. All participants were treated in agreement with the ethical guidelines of the American Psychological Association with respect to participant consent, confidentiality and anonymity.

2.2 Pre-Study Training of PSPET's

PSPET's were supported in learning about and using the TGM via the study researchers in an undergraduate class for PSPET's. Before the initial class session introducing TGM to the students, instructors provided several readings focused on TGfU and TGM. The variety of readings provided PSPET's with foundational knowledge focusing on history, tenets, instruction, and assessment used within each. During the initial class session, PSPET's were provided PowerPoint presentations, YouTube videos, and interactive class discussion building on knowledge gained by the readings.

After the initial class, subsequent sessions involved PSPET's participating in practical experiences provided by the class instructors. Modeling of practical sessions included two invasion games (i.e., Frisbee and lacrosse) and two net-wall games (i.e., badminton and pickleball). Throughout the practical sessions, instructors facilitated whole class and small group discussion through using questions to engage the PSPET's and make explicit the important elements of teaching through the TGM. These sessions were taken from Mitchell, Oslin, and Griffin (2013) and were lessons not being taught by the PSPET's later. PSPET's also completed a reflective journal regarding their experiences of the TGM during the initial lectures and modeling sessions, as well as during their experiences in teaching using TGM, and participating in TGM sessions delivered by their peers. The purpose of the reflective journal was for the PSPET's to individually reflect on their experiences of using TGM (Harvey & O'Donovan, 2013). The journals are not included in this study but are mentioned here as they were significant in dealing with 'dilemmas' that PSPET's had about using TGM in k-12 teaching settings (Harvey, Cushion, & Sammon, 2015).

2.3 PSPET's Teaching of TGM Sessions

After participating in model sessions delivered by the two course instructors from within the same games, PSPET's peer taught one TGM lesson within invasion (lacrosse and Frisbee) and/or net/wall (badminton and pickleball) games using content from *Teaching Sports Concepts and Skills: A Tactical Games Approach* (Mitchell, Oslin, & Griffin, 2013). Each PSPET's was therefore solely responsible for leading one lesson in one of the sport areas. Consequently, 24 lessons were delivered in total, six from each game and each of the 24 lessons was led by a different PSPET. Due to time constraints in the university-based course, PSPET's were advised their lessons would only be allowed to last 25 mins. The actual average lesson time was slightly longer at 25 minutes 15 seconds.

2.4 Instruments

The research team was present during each class to collect data on PSPET's fidelity to the model, lesson context and teacher behavior. They also assisted PSPET's if they needed support with accelerometers.

2.4.1 Model Benchmarks

The TGM lessons were assessed using benchmarks to ensure that lessons were implemented correctly and not detrimental to learning outcomes (Metzler, 2011). While benchmarks offer key criteria to determine if the teacher is 'doing the model' it has been suggested that not all benchmarks need to be met when using curriculum models (Hastie & Casey, 2014). For this study, we followed the lead of Gurvitch, Blankenship, Metzler, and Lund (2008) and Harvey et al., (2016b) in selecting four key 'non-negotiable' teacher benchmarks, which included: teacher uses tactical problems as the organizing center for the learning tasks, teacher begins each lesson with a game form to assess students' knowledge, teacher uses deductive questions to get students to solve tactical problems, teacher uses high rates of guides and feedback during situated learning tasks. 'Non-negotiable' student benchmarks utilized for model fidelity were: students are given time to think about deductive questions regarding the technical problem, students understand how to set up situated learning tasks, students are making situated tactical decisions, game modifications developmentally appropriate (for a complete list of model benchmarks, see Metzler, 2011).

2.4.2 Lesson Context Data

Lesson context was coded using definitions from the System for Observing Fitness Instruction Time (SOFIT) training manual (McKenzie, 2012). This involved coding the context of the lesson every 20 seconds (McKenzie, 2012). Lesson context codes were recorded as follows; M = general content (transition, break, management), P = knowledge content (physical fitness), K = general knowledge (rules, strategy, social behavior, technique), F = motor content fitness, S = skill practice and G = game play.

The first author conducted the SOFIT coding. One additional coder assisted with inter-observer agreement. Both the first author and the additional coder conducted all four parts of the SOFIT training included in the SOFIT manual and reached the acceptable levels of Inter Observer Agreement (IOA) with the gold standard within the lesson context section. When acceptable IOA levels (i.e., 80%) were reached (McKenzie, 2012), the additional observer undertook live coding on two occasions alongside the first author. On each occasion, acceptable IOA levels above 80% were reached (McKenzie, 2012).

2.4.3 Teacher Behavior Data

Teacher behavior data were collected using the West Virginia Teaching Evaluation System (WVUTES; Hawkins & Wiegand, 1989)[ii]. While initially developed for use with computer-based software, in this study the traditional paper and pencil method was employed. The WVUTES instrument includes the following 11 behaviors: general observation, specific observation, encouragement, positive feedback, negative (corrective) feedback, management, verbal instruction, modeling, physical guidance,

[ii] The behavior categories of the WVUTES can be obtained from the first author.

non-task verbal and off-task. To align with data collected via lesson context, teacher behaviors were also coded every 20s using momentary time sampling. One behavior per interval was recorded. If two behaviors were evident in the same interval, the behavior with the higher ranking was recorded. For example, if both corrective feedback (ranked number 4) and general verbal instruction (ranked number 6) were noted within the same interval, general verbal instruction, i.e., the higher ranked variable, would be recorded. This instrument has previously been utilized in the context of the TGM literature (Harvey et al, 2016a).

The first author conducted the teacher behavior coding. One additional coder assisted with inter-observer agreement. To align with data collected via lesson context, teacher behavior coder training followed the same process as lesson context, and utilized the same videotaped records. Gold standard records of behaviors for each videotaped record from all four parts of the SOFIT training were constructed by the first author who reached acceptable IOA levels (McKenzie, 2012) with one of the originators of the WVUTES instrument (Potrac, Jones and Armour, 2002). The additional coder then coded these same videotaped records and reached acceptable IOA levels with the first author (McKenzie, 2012).

2.4.4 Accelerometry

PSPET's wore ActigraphGTX3® triaxial accelerometers to collect physical activity data. PA levels during each lesson were measured using Actigraph GT3X® triaxial accelerometers (Pensecola, FL). The GT3X® measures acceleration of movement across three axes (x, y and z) and these data are subsequently converted to activity counts. The GT3X® activity counts for moderate and vigorous have been validated through indirect calorimetry (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008; Trost, Loprinzi, Moore, & Pfeiffer, 2011). The thresholds (counts/min) of Troiano et al. (2008) were used in this study: moderate 2020 (3 METs) and vigorous 5999 (6 METs).

Each participant was assigned a specific identification (ID) number by the first/second author. Accelerometers with these corresponding numbers were pre-programmed by one of the authors for the individual specifications of each participant (i.e., height, weight, date of birth). Stature and body mass were measured using standardized procedures (CDC, 2011)[iii] and each PSPET consented to provide date of birth information and approval was granted by the Institutional Review Board.

PSPET's were provided an accelerometer for duration of the class, lasting three weeks. PSPET's placed the accelerometer onto their waistband and wore the accelerometer while they participated in the TGM lessons delivered by their peers.

[iii] Stature and body mass (calibrated Tanita BF-682 scales; Tanita Corp, Tokyo) were measured to the nearest 0.1cm and 0.1kg.

After the final lesson on each activity area was completed, the devices were returned into the correct clear plastic bags by the PSPET's, placed into a box and taken back to the first author's office. The devices were connected to a personal password protected computer and the information downloaded via the Actigraph software. The utilization of the Actigraph software permitted GT3X® activity counts for each lesson at a 1-second epoch. Data were extracted by applying a filter with the specific times of the lesson, which had previously been noted during data collection during class. This enabled the mean percentage of time spent in MVPA and VPA to be calculated using the previously cited Troiano et al. (2008) cut off points. These data were then exported from the Actigraph software to Microsoft Excel™ for subsequent data management before being imported into Version 24.0 of SPSS (SPSS Inc, Chicago, IL) for statistical analyses.

2.4.5 Observer Reliability

For model benchmarks, Inter-observer reliability checks were performed on three of the 24 sessions (12.5% of the data, as recommended by McKenzie, 2012). Inter-observer reliability for these three sessions was 100%, 88%, and 100%, averaging 96%.

Inter-observer reliability checks for lesson context data were also completed on three of the 24 sessions (randomly selected based on observer availability and training; McKenzie, 2012). Interval-by-interval agreement between observers averaged 94.58% (range 90.41-97.70%), which exceeded minimum levels of agreement (McKenzie, 2012).

Inter-observer reliability checks for teacher behavior data on three of the 24 sessions (randomly selected based on observer availability and training; McKenzie, 2012) demonstrated interval-by-interval agreement between observers averaging 86.67% (range 80.82-90.80%), which exceeded minimum levels of agreement (McKenzie, 2012). In all instances, scores from the lead observer were used in subsequent data analyses (McKenzie, 2012).

2.5 Data Analysis

2.5.1 Model Benchmarks

The benchmark chart for TGM in Metzler (2011) was used to assess PSPET video recorded lessons. Sessions were reviewed from video-taped records with check marks being placed under one of the following criteria 'very well', 'ok', or 'not present' associated with one of the eight selected TGM benchmarks (four teacher, four student; Gurvitch et al., 2008; Harvey et al., 2016b).

2.5.2 Lesson Context and Teacher Behavior Data

Descriptive lesson context and teacher behavior data (means and standard deviations) were calculated using percent of class time as the unit of measurement following standard protocols outlined by McKenzie (2012) for the SOFIT protocol and Hawkins and Wiegand (1989) for the WVUTES. For example, the percent of class intervals students spent in each lesson context/teacher behavior category were calculated for each lesson and a mean percentage score computed over the course of the 24 (n = 6 for each sport) observed lessons.

2.5.3 Accelerometry

Once accelerometry data for each PSPET had been downloaded for each lesson by the researchers and exported to SPSS, this enabled computation of mean scores for MVPA/VPA over the 24 (n = 6 for each sport) lessons. Accelerometers that did not contain any data either due to absence or neglecting to wear the device were excluded. All available data was therefore included in subsequent analyses.

Accelerometer data were analyzed using repeated measures ANOVA. Two separate repeated measures ANOVAs were employed to assess any differences in MVPA/VPA between the invasion and net-wall games. Alpha level was set at $p < 0.05$, with a confidence interval for differences of 95%. Version 24.0 of SPSS (SPSS Inc, Chicago, IL) was used for all statistical analyses.

3. Results

3.1 Model Benchmarks

Model benchmarks were recorded in all 24 lessons. Table 1 provides information about the results generated from the TGM teacher benchmarks. One PSPET did not begin their session with a game. The 23 other PSPET's met the benchmark scoring 'ok'. Similarly, one PSPET (the same one as previously highlighted) did not begin their session by explicitly focusing on tactical problem as the organizing center of the learning task. However, the other 23 PSPET's did 'ok' on that benchmark. The benchmark focusing on teacher's using inductive questions to solve tactical problems was met with two PSPET's scoring 'very well' and the remaining 22 'ok'. The benchmark, teacher's using high rates of feedback had two PSPET's score 'very well' and 22 scoring 'ok'. Thus, these data suggest the PSPET's were doing the model with acceptable fidelity.

The model student benchmarks are shown in Table 2. In evaluating the results generated from the TGM student model benchmarks PSPET's met all student benchmarks with ratings of 'ok' to satisfy the PSPET's were doing the model with acceptable fidelity.

3.2 Lesson Context and Teacher Behavior Data

Lesson context data showed that teachers spent most of their time in game play, followed by skill practice, with the remaining time spent in knowledge and management (see Table 3 for specific mean and standard deviations).

The teachers primarily used verbal instruction, followed by general observation, management, positive feedback, specific observation, corrective feedback, and modeling (see Table 4 for specific mean and standard deviations). Corrective feedback and modeling were low, each lower than 7% of the total behaviors utilized (see Table 4).

3.3 Accelerometry

For the two invasion games of Frisbee and lacrosse, the results showed there was a significant effect of game type on both MVPA and VPA; $F(1,22) = 21.32$, $p > 0.001$, $\eta p2 = .52$, $F(1,22) = 48.67$, $p > 0.001$, $\eta p2 = .89$, respectively (see Table 5 for specific means and standard deviations). For the two net-wall games of pickelball and badminton, the results showed there was a significant effect of game type for MVPA only; $F(1,22) = 30.68$, $p > 0.001$, $\eta p2 = .58$ (see Table 5 for specific means and standard deviations).

4. Discussion

This study used direct observation, accelerometry, and PSPET teaching to examine MVPA during a TGM lesson episode delivered by PSPET's. Findings show that students did not reach the suggested recommendations of 50% MVPA during any of the four activities. However, invasion activities, Frisbee and lacrosse, provided significantly greater opportunities for MVPA/VPA than the net/wall activities, badminton and pickleball, with Frisbee recording the highest levels of MVPA/VPA out of the four activities areas studied. Results are consistent with previous research showing invasion activities are proficient in getting a high measurement of MVPA in PE (i.e., Brusseau & Burns, 2016; Fairclough & Stratton, 2005, 2006). Net and wall activities show a marked decrease in trying to attain 50% MVPA in contrast to invasion activities. For example, Aelterman et al. (2012) previously found that physical activity varied according to the activity. Racquet sports provided lesser opportunities for physical activity where other activities provided more.

One reason that PSPETs may not have technically met slated recommended activity levels is the nature of the measurement tool used in the current study. Research shows that teachers using GCAs such as the TGM can meet PA recommendations when MVPA has been measured using SOFIT (Harvey et al., 2016a), heart rate monitors (Van Acker et al., 2010), and/or different brands of accelerometers with different cut off points (Smith et al., 2015). Indeed, there is an association between the MVPA accrual in the current study and a previous study by Harvey et al. (2016b) who utilized the exact same brand of accelerometer. That said, Harvey and colleagues found higher levels of VPA, though this may be due to the VPA cut-off points for Evenson (4011) being lower than those of Troiano (5999) used in the current study. An important point, however, is for more studies to be conducted using similar measurement tools so that results of these studies can be compared. As identified above, the reporting of some studies meeting slated guidelines may be due to the measurement tool used rather than the quality of the TGM teaching observed. Thus, the importance of benchmarking and cataloguing lesson context and teacher behavior is hugely important so results can be contextualized when presented.

However, although PSPET's did not accrue 50% MVPA in any of the four activities studied, we contend that using GCAs such as the TGM is potentially affords students opportunities to be more active when compared to games lessons focused on direct instruction (i.e., Dania et al., 2017; Harvey et al., 2015a, 2016a, b; Miller et al., 2015, 2016; Smith et al., 2016; Van Acker et al., 2010; Yelling et al., 2001). Roberts and Fairclough (2011) found that physical education lessons centered on the direct instruction model resulted in high levels of inactivity. They argued this was related to (a) high levels of teacher management time, (b) too much time in lessons being centered on skill and drill practice, and (c) the teachers' overuse of full-sided versions of games (e.g., 11 vs. 11 soccer or 5 vs. 5 basketball). Moreover, researchers argue using the TGM is one of the best ways to concurrently meet psychomotor, cognitive and affective goals in physical education (Harvey et al., 2016a).

Another factor that future studies may look to investigate in more detail, however, is the MVPA/VPA accrued in the actual activity itself (i.e., game form or skill-based activity) rather than over the course of the whole lesson like we did in this study. What we do not know, therefore, is which activity of the different activities (game or skill) permitted PSPET's to accrue greater levels of MVPA/VPA, and if the PA levels accrued *within* these different activities was consistent with national recommendations. Knowing more about this accrual within the activities themselves may enable teachers to plan their lessons accordingly if they want to emphasize PA or a particular PA outcome.

That said, we would still contend that lessons delivered through GCAs such as the TGM offer teachers the opportunity to concurrently meet psychomotor, cognitive and affective goals in physical education, especially if they maintain a 70:20:10 ratio of practice (whether this be game-based or skill learning), knowledge and classroom management, respectively, as previously recommended by Harvey et al., (2016a). That said, data from the current study provide evidence of a juxtaposition between the teachers need to meet physical activity recommendations and the cognitive elements associated with games that are a focus of the TGM, especially given a central tenet of GCAs such as TGM is questioning, dialogue, debate and discussion (Light, 2008), so time needs to be dedicated by the teacher to using provocations or having students unpack game concepts and processes. Additionally, some lessons may not be as active as students need to spend more time in skill development practices. The notion for the teacher is to gain experiences in using the TGM so they learn to balance PA (game play and skill practice) and cognitive engagement, as development in one area helps the other. Moreover, we appreciate that the results gained from the current study may have been mediated by the teachers' limited experiences of TGM delivery. As such we would expect MVPA accrual to increase as PSPET's fidelity to the model as teachers moved from simply 'ok' to 'very well' and as students became more accustomed to experiencing lessons where their teachers use the TGM. Future studies to be undertaken to better understand more about how model fidelity affects student activity and learning.

There are strengths and limitations of any study. The strengths of the current study were that it provided teachers with an experience teaching a lesson using TGM, and used an objective measure of PA (i.e., accelerometry). It also measured MVPA during TGM invasion and net/wall game lessons. An important aspect of the study was that instructors/researchers with substantial experience facilitated the PSPET's learning of TGM. An enabling environment that nurtured PSPET's learning about and implementing TGM was created through the instructors scaffolding PSPET's learning progression which included classroom lectures and discussion, participating in lessons taught by the course instructors/researchers, to finally independently teaching a lesson in the TGM using an invasion or net/wall activity. This experience enabled them to realize some of the 'dilemmas' of teaching with TGM (Harvey et al., 2015b), while doing so in a somewhat 'safe' environment, where the instructors/researchers provided constructive feedback based on the teaching episodes, which was supplemented by PSPET's completing a series of reflective journal prompts PSPET's after each episode/class.

Some limitations that should be addressed from the current studies include the utilization of only one specific PETE course in a single geographical area at one university. As such, results do not provide generalizability to any other PETE program or PSPET. The sample size, limited number of teaching episodes using TGM, and no experience with TGM throughout PSPET program until before student teaching semester could contribute to the results presented earlier. Due to the circumstances of course offering and the number of PSPET enrolled, the limitations could not be addressed. A limited number of invasion sessions had to be moved indoors due to weather and did not use the same area of space indoors as was used outdoors for the other lessons of invasion activities. A study over time using multiple PSPET cohorts may reveal different results. Finally, using invasion and net/wall classifications with PSPET's teaching only one of the activities should be considered when interpreting results.

5. Conclusions

PSPET's did not reach national MVPA recommendations during any of the sessions focused on the different games types. VPA was also lower than recorded in previous studies. PSPET's accrued greater levels of MVPA/VPA in invasion games. Results may have been mediated by the teachers' limited experiences of TGM delivery.

6. Recommendations

Studies such as the present one provide information that is important to the physical activity levels of students in PE classes. By incorporating an instructional model such as the TGM teachers can concurrently meet psychomotor, cognitive and affective goals in physical education. This study provides the need to further investigate PSPET's development in learning about and using the TGM in a public-school setting during the student teaching semester. MVPA should be measured during this process to continue to build on research in the current study. Moreover, if PSPET's are expected to implement TGM during student teaching, universities need to provide professional development experiences in TGM for the public-school PE teachers who supervise student teaching experiences.

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References

1. Aelterman, N., Vansteenkiste, M., Van Keer, H., Van den Berghe, L., De Meyer, J., & Haerens, L. (2012). Students' objectively measured physical activity levels and engagement as a function of between-class and between-student differences in motivation toward physical education. *Journal of Sport & Exercise Psychology*, 34, 457-480.
2. Andersen, L., Harro, M., Sardinha, L., Froberg, K., Ekelund, U., Brage, S., & Anderssen, S. (2006). Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *The Lancet*, *368*(9532), 299-304.
3. Association for Physical Education. (2008). Health Position Paper. *Physical Education Matters*, *3*(2), 8-12.
4. Brusseau, T., & Burns, R. (2016). Step count and MVPA compendium for middle school physical education activities. *Journal of Physical Education & Sport*, *15*(4), 646 - 650.
5. Butler, J., & McCahan, B. (2005). Teaching games for understanding as a curriculum model. In L. Griffin & J. Butler, *Teaching Games for Understanding: Theory, research, and practice* (pp. 33-54). Champaign, IL: Human Kinetics.
6. Centers for Disease Control and Prevention. (2011). *National Health and Nutrition Examination Survey: Anthropometry Procedures Manual*. Atlanta, GA: Unites States Department of Health and Human Services. Retrieved from http://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/Anthropometry_Procedures_Manual.pdf
7. Dania, A., Kossyva, I., & Zounhia, K. (2017). Effects of a teaching games for understanding program on primary school students' physical activity patterns. *European Journal of Physical Education and Sport Science*, *3*(2), 81-94.

8. Denton, S., Trenell, M., Plötz, T., Savory, L., Bailey, D., & Kerr, C. (2013). Cardiorespiratory fitness is associated with hard and light intensity physical activity but not time spent sedentary in 10–14 year old schoolchildren: the HAPPY study. *Plos ONE*, *8*(4), e61073.
9. Department of Health. (2011). *Start Active, Stay Active: A report on physical activity for health from the four home countries' Chief Medical Officers*. London: HMRC. Retrieved from https://www.gov.uk/government/publications/uk-physical-activity-guidelines
10. Evenson, K., Catellier, D., Gill, K., Ondrak, K., & McMurray, R. (2008). Calibration of two objective measures of physical activity for children. *Journal of Sports Sciences*, *26*(14), 1557-1565.
11. Fairclough, S., & Stratton, G. (2005). Physical activity levels in middle and high school physical education: A review. *Pediatric Exercise Science*, *17*(3), 217-236.
12. Fairclough, S., & Stratton, G. (2006). A review of physical activity levels during elementary school physical education. *Journal of Teaching in Physical Education*, *25*(2), 240-258.
13. Gray, S., Sproule, J., & Morgan, K. (2009). Teaching team invasion games and motivational climate. *European Physical Education Review*, *15*(1), 65-89.
14. Griffin, L., Oslin, J., & Mitchell, S. (2006). *Teaching sport concepts and skills: A tactical games approach* (2nd ed.). Champaign: IL: Human Kinetics.
15. Gurvitch, R., Blankenship, B., Metzler, M., & Lund, J. (2008). Student teachers' implementation of model-based instruction: Facilitators and inhibitors. *Journal of Teaching in Physical Education*, *27*(4), 466-486.
16. Harvey, S., & Jarrett, K. (2014). A review of the game-centred approaches to teaching and coaching literature since 2006. *Physical Education & Sport Pedagogy*, *19*(3), 278-300.
17. Harvey, S., & O'Donovan, T. (2013). Pre-service physical education teachers' beliefs about competition in physical education. *Sport, Education & Society*, *18*(6), 767-787.
18. Harvey, S., Cushion, C., & Massa-Gonzalez, A. (2010). Learning a new method: Teaching Games for Understanding in the coaches' eyes. *Physical Education & Sport Pedagogy*, *15*(4), 361-382.
19. Harvey, S., Smith, L., Fairclough, S., Savory, L., & Kerr, C. (2015a). Investigation of pupils' levels of MVPA and VPA during physical education units focused on direct instruction and tactical games models. *The Physical Educator*, *72*, 40-58.

20. Harvey, S., Cushion, C., & Sammon, P. (2015b). Dilemmas faced by pre-service teachers when learning about and implementing a game-centred approach. *European Physical Education Review*, *21*(2), 238-256.
21. Harvey, S., Song, Y., Baek, J., & van der Mars, H. (2016a). Two sides of the same coin: Student physical activity levels during a game-centred soccer unit. *European Physical Education Review*, *22*(4), 411-429.
22. Harvey, S., Smith, M., Song, Y., Robertson, D., Brown, R., & Smith, L. (2016b). Gender and school-level differences in students' moderate and vigorous physical activity levels when taught basketball through the tactical games model. *Journal of Teaching in Physical Education*, *35*(4), 349-357.
23. Hastie, P. & Casey, A. (2014). Fidelity in models-based practice research in sport pedagogy: A guide for future investigations. *Journal of Teaching in Physical Education*, *33*(3), 422-431.
24. Hawkins, A., & Wiegand, R. (1989). West Virginia University teaching evaluation system and feedback taxonomy. In P. Darst, R. Zakrajsek & V. Mancini, *Analyzing Physical Education and Sport Instruction* (pp. 277-293). Champaign, IL: Human Kinetics.
25. Hopkins, N., Stratton, G., Tinken, T., McWhannell, N., Ridgers, N., & Graves, L. et al. (2009). Relationships between measures of fitness, physical activity, body composition and vascular function in children. *Atherosclerosis*, *204*(1), 244-249.
26. Institute of Medicine. (2013). *Educating the student body: Taking physical activity and physical education to school*. Washington DC: The National Academies Press.
27. Kirk, D. (1983). Theoretical guidelines for "teaching for understanding". *Bulletin of Physical Education*, *19*(1), 41-45.
28. Kirk, D. (2010). *Physical education futures.* London & New York: Routledge.
29. Kirk, D. (2013). Educational value and models-based practice in physical education. *Educational Philosophy & Theory*, *45*(9), 973-986.
30. Kirk, D., & Macdonald, D. (1998). Situated learning in physical education. *Journal of Teaching in Physical Education*, *17*(3), 376-387.
31. Lee, M., & Ward, P. (2009). Generalization of tactics in tag rugby from practice to games in middle school physical education. *Physical Education & Sport Pedagogy*, *14*(2), 189-207.
32. Light, R. (2008). Complex Learning Theory—Its epistemology and its assumptions about learning: Implications for physical education. *Journal of Teaching in Physical Education*, *27*(1), 21-37.
33. McKenzie, T. (2012). *SOFIT. System for Observing Fitness Instruction Time. Overview and training manual*. San Diego, CA: San Diego State University.

34. Metzler, M. (2011). *Instructional models for physical education* (3rd ed.). Scottsdale, AZ: Holcomb Hathaway.
35. Miller, A. (2015). Games centered approaches in teaching children & adolescents: Systematic review of associated student outcomes. *Journal of Teaching in Physical Education*, *34*(1), 36-58.
36. Miller, A., Christensen, E., Eather, N., Gray, S., Sproule, J., Keay, J., & Lubans, D. (2016). Can physical education and physical activity outcomes be developed simultaneously using a game-centered approach? *European Physical Education Review*, *22*(1), 113-133.
37. Miller, A., Christensen, E., Eather, N., Sproule, J., Annis-Brown, L., & Lubans, D. (2015). The PLUNGE randomized controlled trial: Evaluation of a games-based physical activity professional learning program in primary school physical education. *Preventive Medicine*, *74*, 1–8.
38. Mitchell, S., Oslin, J., & Griffin, L. (2013). *Teaching of sports concepts and skills: A tactical games approach* (3rd ed.). Champaign, IL: Human Kinetics.
39. Oslin, J., & Mitchell, S. (2006). Game-centered approaches to teaching physical education. In D. Kirk, D. MacDonald & M. O'Sullivan, *The handbook of physical education* (pp. 627-651). London: Sage.
40. Potrac, P., Jones, R., & Armour, K. (2002). 'It's all about getting respect': The coaching behaviours of an expert English soccer coach. *Sport, Education &d Society*, *7*(2), 183-202.
41. Roberts, S., & Fairclough, S. (2011). Observational analysis of student activity modes, lesson contexts and teacher interactions during games classes in high school (11-16 years) physical education. *European Physical Education Review*, *17*(2), 255-268.
42. Ruiz, J., Rizzo, N., Ortega, F., Wärnberg, J., & Sjöström, M. (2006). Relations of total physical activity and intensity to fitness and fatness in children: the European Youth Heart Study. *American Journal of Clinical Nutrition*, *84*(2), 299-303.
43. Smith, L., Harvey, S., Savory, L., Fairclough, S., Kozub, S., & Kerr, C. (2015). Physical activity levels and motivational responses of boys and girls: A comparison of direct instruction and tactical games models of games teaching in physical education. *European Physical Education Review*, *21*(1), 93-113.
44. Troiano, R., Berrigan, D., Dodd, K., Mâsse, L., Tilert, T., & McDowell, M. (2008). Physical Activity in the United States Measured by Accelerometer. *Medicine & Science in Sports & Exercise*, *40*(1), 181-188.

45. Trost, S., Loprinzi, P., Moore, R., & Pfeiffer, K. (2011). Comparison of accelerometer cut points for predicting activity intensity in youth. *Medicine & Science in Sports & Exercise*, *43*(7), 1360-1368.
46. Van Acker, R., da Costa, F., De Bourdeaudhuij, I., Cardon, G., & Haerens, L. (2010). Sex equity and physical activity levels in coeducational physical education: exploring the potential of modified game forms. *Physical Education & Sport Pedagogy*, *15*(2), 159-173.
47. Vande Broek, G., Boen, F., Claessens, M., Feys, J., & Ceux, T. (2011). Comparison of three instructional approaches to enhance tactical knowledge in volleyball among university students. *Journal of Teaching in Physical Education*, *30*(4), 375-392.
48. Yelling, M., Penney, D., & Swaine, I. (2000). Physical activity in physical education: A case study investigation. *European Journal of Physical Education*, *5*(1), 45-66.

Table 1: PSPET TGM teacher benchmarking

Teacher Benchmark	Activity (No. of Sessions)	NO	OK	Very Well
Teacher uses a tactical problem as the organizing center for learning tasks.	Frisbee (6)	1	5	0
	Lacrosse (6)	0	6	0
	Badminton (6)	0	6	0
	Pickleball (6)	0	6	0
Teacher begins each unit segment with a game form to assess student knowledge.	Frisbee (6)	1	5	0
	Lacrosse (6)	0	6	0
	Badminton (6)	0	6	0
	Pickleball (6)	0	6	0
Teacher uses deductive questions to get students to solve the tactical problem.	Frisbee (6)	0	5	1
	Lacrosse (6)	0	6	0
	Badminton (6)	0	6	0
	Pickleball (6)	0	5	1
Teacher uses high rates of guides and feedback during situated learning tasks.	Frisbee (6)	0	5	1
	Lacrosse (6)	0	6	0
	Badminton (6)	0	5	1
	Pickleball (6)	0	6	0

Table 2: PSPET TGM student benchmarking

Student Benchmark	Activity (No. of Sessions)	NO	OK	Very Well
Students are given time to think about deductive questions regarding the tactical problem.	Frisbee (6)	0	6	0
	Lacrosse (6)	0	6	0
	Badminton (6)	0	6	0
	Pickleball (6)	0	6	0
Students understand how to set up situated learning tasks.	Frisbee (6)	0	6	0
	Lacrosse (6)	0	6	0
	Badminton (6)	0	6	0
	Pickleball (6)	0	6	0
Students are making situated tactical decisions.	Frisbee (6)	0	6	0
	Lacrosse (6)	0	6	0
	Badminton (6)	0	6	0
	Pickleball (6)	0	6	0
Game modifications are developmentally appropriate.	Frisbee (6)	0	6	0
	Lacrosse (6)	0	6	0
	Badminton (6)	0	6	0
	Pickleball (6)	0	6	0

Table 3: Percent time spent in different lesson contexts in TGM lessons taught by PSPET's

Lesson Context	Frisbee	Lacrosse	Pickelball	Badminton
	M (±SD)	M (±SD)	M (±SD)	M (±SD)
Management	12.02 (2.44)	11.18 (2.33)	12.67 (2.79)	11.11 (1.78)
Knowledge	19.64 (3.20)	16.99 (5.06)	16.78 (5.17)	17.83 (1.90)
Skill Practice	33.82 (3.20)	33.97 (6.76)	26.65 (13.81)	37.23 (4.25)
Game	34.52 (6.15)	37.86 (7.80)	43.89 (9.85)	33.82 (4.07)
Total	100	100	100	100

Table 4: Percent time spent in different teacher behaviors in TGM lessons taught by PSPET's

Lesson Context	Frisbee	Lacrosse	Pickelball	Badminton
	M (±SD)	M (±SD)	M (±SD)	M (±SD)
General observation	18.03 (5.54)	14.85 (8.44)	20.38 (6.64)	12.86 (5.40)
Encouragement	0.43 (0.67)	1.06 (1.27)	0.70 (0.77)	0.45 (0.70)
Positive feedback	9.58 (4.53)	7.36 (3.39)	8.87 (3.56)	9.63 (2.23)
Corrective feedback	5.96 (2.91)	7.75 (4.09)	6.24 (4.17)	7.84 (2.79)
Management	11.52 (3.51)	12.31 (4.60)	16.08 (4.90)	11.97 (3.64)
Verbal instruction	36.53 (5.63)	41.49 (10.27)	29.27 (8.56)	37.16 (11.22)
Modeling	3.54 (5.71)	5.32 (2.90)	6.58 (4.64)	9.11 (5.22)
Physical guidance	0.23 (0.56)	0.00 (0.00)	0.24 (0.59)	0.00 (0.00)
Non-task verbal	0.90 (1.11)	0.89 (0.69)	2.07 (1.71)	2.86 (2.78)
Off-task	4.48 (4.19)	2.86 (2.00)	1.15 (1.03)	1.88 (2.51)
Specific observation	8.80 (5.42)	6.13 (2.87)	8.42 (3.65)	6.25 (2.79)
Total	100	100	100	100

Table 5: MVPA and VPA percentage according to activity

School	Activity	% activity M (±SD)	CI (95%)
Frisbee	MVPA	31.39 (±6.04)	28.78-34.00
	VPA	8.68 (±3.22)	7.29-10.07
Lacrosse	MVPA	27.80 (±6.78)	24.87-30.74
	VPA	6.57 (±6.56)	5.46-7.68
Pickelball	MVPA	24.85 (±6.06)	22.23-27.48
	VPA	4.81 (±2.04)	3.93-5.70
Badminton	MVPA	20.91 (±5.77)	18.42-23.41
	VPA	4.37 (±2.31)	3.37-5.36