Original Research

SAM: A Tool for Measurement of Moderate to Vigorous Physical Activity (MVPA) in School Physical Education

KAMPOL SURAPIBOONCHAI†[1], STEVEN R. FURNEY‡[1], ROBERT F. REARDON‡[1], JAMES ELDRIDGE‡[2], and TINKER D. MURRAY‡[1]

[1]Texas State University, San Marcos, TX, USA; [2]University of Texas at the Permian Basin,

‡Denotes professional author, †Denotes graduate student author

ABSTRACT

Int J Exerc Sci 5(2) : 127-135, 2012. Observational methods have been a primary methodology used by physical educators for assessing teacher and student behaviors in school physical education (PE) classes for over 30 years. Observational instruments traditionally used in PE are economical, but are time intensive and complicated. Recently national PE recommendations have been promoted to encourage practitioners to achieve ≥ 50% of PE class in moderate to vigorous physical activity (MVPA). The purpose of this preliminary study was to develop, validate, and test the reliability of the Simple Activity Measurement (SAM) instrument for assessing MVPA during school PE classes. Students (N=36, representing grades 3-10) from a convenient sample of schools in San Antonio, TX were randomly selected to wear SUUNTOTM heart rate (HR) monitors during PE classes as an MVPA intensity measure, and the SAM instrument was used to observe 6 classes (N=281 students) for MVPA each minute using the SAM 0-10 scale. The SAM instrument was found to be a significant predictor for HR ($r=0.555$, $r2=0.308$, $p<0.05$) using linear regression, and the intra class correlation coefficient to test reliability was found to be $R=0.803$, $p<0.05$. Students averaged 88.5 % of class time spent in MVPA at the elementary level and only 36.5 % of class time spent in MVPA at the high school level. The results of this preliminary study indicate that the SAM has promise to provide school PE evaluators with an effective economical observation tool to document minutes of student MVPA in PE classes, and to promote accountability with national MVPA recommendations.

KEY WORDS: Youth, observational research, heart rate monitoring, public health policy

INTRODUCTION

Preventing and controlling childhood overweight and obesity is challenging for public health and school professionals, as the incidence has increased dramatically in the past 40 years (13, 24). When compared to normal weight youth, overweight or obese children and adolescents are more likely to become overweight or obese adults, have an early onset of metabolic health risks like hypertension, high cholesterol, and type 2-diabetes, and have an increased chronic disease risk (e.g., heart disease, stroke, and cancers) (13, 22).

School-based physical education (PE) is usually recommended as an effective intervention to increase physical activity (PA) in children and adolescents (6, 18).

Regular PA is associated with a decreased risk of type-2 diabetes, cardiovascular disease and some cancers among adults (21, 22). Moderate to vigorous intensity physical activity (MVPA) is associated with improved cardiovascular endurance, increased muscle and bone strength, improved glycemic status and lipid levels and lower BMI among youth (19). Increasing MVPA in PE also provides more opportunities to positively influence adolescents with regards to social interactions, psychological development, motor development, and the adoption of more active lifestyles (18, 25).

The 2008 Physical Activity Guidelines for Americans recommends that children and adolescents participate in at least 60 minutes of MVPA most days of the week, preferably daily, in order to attain health benefits (19, 21). To help reach this national goal, the Centers for Disease Control and Prevention (CDC) recommends that students be engaged in MVPA for at least 50 percent of PE class time (23). Advocates of this recommendation have suggested using it as an accountability measure for school PE (18). Jago et al. has recently shown that PE can be readily modified so that students spend more than 50% of time in MVPA (defined as a heart rate - HR between 130-140 beats/minute) (5).

It is difficult for researchers and practitioners to choose a school-based PA tool that is economical and yet effective at measuring MVPA. Sophisticated measures for measuring PA levels, like accelerometers, global positioning sensors (GPS), and heart rate monitors, are expensive and have limitations for use with large groups (10). Observational methods such as the System for Observing Fitness Instruction Time (SOFIT - designed to assess the quality of PE instruction along with student PA levels monitored every 20 seconds) (8), and Academic Learning Time-Physical Education (ALT-PE – focused more on measuring physical skills versus MVPA levels) (14), are traditional instruments that are economical, but can be complicated and time consuming. Other newer electronic observational methods like OBSERVA (3) and Bonnie's Fitware (2) allow PE evaluators to use handheld technology to observe teacher and student behavior, and store data for future use, but have other technology requirements that some schools do not have, or cannot afford. The OBSERVA and Bonnie's Fitware instruments use multiple observational detailed categories like those found in SOFIT and ALT-PE. In addition, most observational methods available focus more on teacher behavior, than student behavior, and are time intensive with regards to interpretation by practitioners/school administrators. For simple accountability, those who evaluate PE may just want feedback about the number of minutes spent in MVPA per PE class, and general class management information.

The Simple Activity Measurement (SAM) is a tool designed from pilot study work performed by the U.S. national, multi-center site, HEALTHY Study (11) for assessing MVPA in PE classrooms, which modifies the SOFIT instrument, and provides basic feedback about instruction and physical activities. The purpose of this preliminary study was to develop, validate, and test the reliability of the SAM instrument for assessing student MVPA during school PE classes related to the potential for evaluating the achievement of ≥ 50% of PE class time spent in MVPA. It

was hypothesized that the SAM measurement instrument could accurately and reliably assess PE curricula and classroom management through the collection of MVPA levels of students as part of school PE evaluation plans.

METHODS

Participants

Initially, forty-eight students from grades 3 - 10 were recruited from the San Antonio Independent School District (SAISD) in San Antonio, TX to participate in the HR criterion measurement portion of the study. The demographics of the whole student study population were representative of that found in the SAISD with 92% considered economically disadvantaged, and 89.5% classified as Hispanic, 7.4% African-American, and 2.7% White (not Hispanic). Due to a variety of school-based methodological issues (e.g. class scheduling conflicts, standardized testing conflicts, instrumentation failures, etc.), complete HR data were obtained for 36 students (18 F, 18 M, representing 6 SAISD schools - 2 elementary, grades 3 and 5; n=12; 2 middle, grades 6,7, and 8; n=12; and, 2 high schools, grades 9 and 10; n=12). Schools were selected based upon convenience and previous contacts with PE teachers via a district in-service promoting increased MPVA levels in PE provided by the lead author. The mean age for students was 12.30±2.34 years, with a mean height of 151.13±13.39 cm, a mean mass of 63.6±26.57 kg, and a mean calculated Body Mass Index (BMI) of 26.91± 27.97 kg/m^2. The means for the demographic data by grade level are presented in table 1. The Texas State University Institutional Review Board (IRB) approved the study protocol (#EXP2010W429), and consents were not required for students to participate in data collection or evaluation activities, since this was already required as part of the general PE curriculum by the SAISD.

Table 1. Demographic Data of the HR Criterion Students

Grade Level	Age (yr)		Height (cm)		Mass (kg)		BMI (kg.m^2)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	8.33	0.52	132.08	4.54	36.63	5.94	20.87	2.42
5	10.57	0.54	150.49	4.81	45.30	7.23	19.90	2.23
6	12.33	1.16	147.32	0.01	43.60	11.56	20.00	5.66
7	12.00	0.01	148.17	16.91	74.93	8.76	34.67	4.51
8	13.86	0.90	155.96	5.26	59.12	6.07	24.40	4.04
9	14.13	0.35	160.44	6.31	90.90	20.75	35.17	7.89
10	15.00	0.01	175.26	3.59	121.71	19.26	40.50	3.25

Instruments

SAM. Figure 1 contains the SAM PE class observational instrument as modified from tools like SOFIT (8) and pilot studies as part of the HEALTHY study (5, 11). The SAM instrument utilizes a modified OMNI scale (16, 17, 20) and Borg (1) type scale for intensity with key descriptors as references for the observer to determine intensity for each minute of PE class. The scale uses 0-3 to represent more sedentary physical activity (e.g. lying down, sitting, standing), 4-6 to represent moderate physical activity (e.g. walking, skipping, bouncing) and 7-10 to represent vigorous physical activity (running, sprinting, jumping rope). Observers are instructed to use initials to describe teaching behavior with categories as follows: A = activity, or I = instruction, to use a number (from the SAM scale, 1-10) to describe the overall level of class activity, and to draw a line to indicate changes/transitions on the nearest whole minute. Once SAM data are collected for a class, the observer can calculate the total

number of MVPA minutes per class in minutes.

SUUNTO™. SUUNTO™ Team Pod Monitors were used to record student HR's during PE classes and to store data for comparisons with SAM observations. The accuracy of SUUNTO™ HR XYZ Monitors are similar to other commercially available HR monitors, but allow HR data to be collected with students only wearing a chest strap.

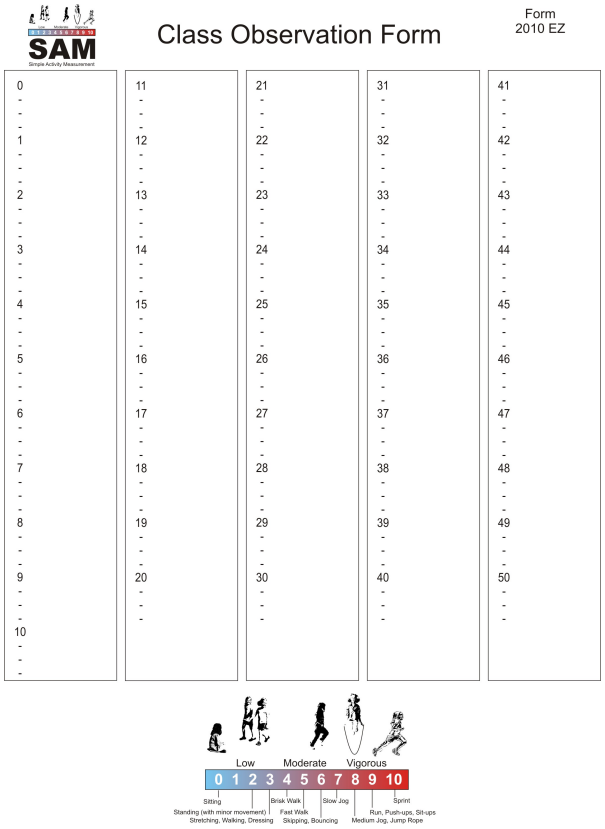

Figure 1. SAM Physical Activity Observation Tool (minutes of class observation and intensity rating scale 0-10)

Experimental Protocol

One experienced SAM observer visited 6 SAISD schools as part of their regular scheduled PE class district evaluation process in the late fall of 2009. Eight students were randomly chosen per class for HR monitoring (SUUNTO™), and the SAM instrument was used to observe 6 classes (one at each school) as a group for levels of MVPA each minute. The PE classes observed included a total of 281 students (125 F, 156 M; range n=17 to 62 students per class). The criteria for determining MVPA using the SAM observational tool was that the class was active at an observed score of greater than 4 on the SAM scale. These scores were later compared with HR data to validate the SAM tool. Moderate intensity activity for the study was defined as a student HR≥130 beats/minute, and vigorous intensity activity was defined as a student HR≥140 beats/minute (4, 5). All students were observed during PE classes that were 45-50 minutes in duration and instructors provided curricular instruction for a variety of PE units (activities included basketball, team handball, or fitness conditioning). These were the PE units being taught at the time of data collection and are representative of the standard curricula of the SAISD school system. Data collection started at the first bell for the class period to start, and ended with the bell signifying the end of the period.

All SAM data were collected and recorded during PE classes, and HR monitoring data were downloaded afterwards for further data analyses. The observed SAM ratings for MVPA during each class transition (e.g. warm-up, instruction, PA) were averaged for each class based upon the number of minutes of observation. Approximately 25 percent of the student HR records (of an original n=48 collected) were lost to interpretation due to recording errors, which is similar to that reported in other

studies using HR monitoring in school youth (4, 5).

Statistical analysis
Normalised ΣW for individual exercises and TWC across trial arm were analysed using a single factor, repeated measures ANOVA with significance quantified using *post-hoc* Student-Neuman-Keuls pair-wise comparisons (InStat, GraphPad Prism, La Jolla, USA). The α level to infer statistical significance was set at $P < 0.05$.

RESULTS

Table 2 contains the mean HR and standard deviations for the corresponding MVPA levels on the SAM scale that were observed (3, 5, 7, and 8). With the limited number of observations in this preliminary study there were only four SAM levels represented from the scale based upon the three PE curricular activities being taught at the time of data collection. School level (elementary, middle school and high school) mean heart rate and percent of age predicted maximal heart rate (HR max) values were as follows: Elementary=170.85 beats/minute with a range of 73 beats/minute representing 81.2% of their age predicted HR max; Middle School=156.85 beats/minute with a range of 69 beats/minute representing 75.8% of their age predicted HR max; High School=135.92 beats/minute with a range of 89 beats/minute representing 66.1% of their age predicted HR max. Table 3 contains the mean percentage of MVPA observed during PE class time by grade level.

To compare the criterion related validity of the SAM instrument to mean HR response a linear regression model was developed. The linear regression revealed that the SAM instrument was a significant predictor for HR ($r=0.555$, $r^2=0.308$, $p<0.05$) with a standard error of estimate of SEE=9.66 beats/minute, and therefore was a valid instrument for predicting HR (figure 2).

Table 2. Comparison of Mean HR Data to the SAM Observational Scale for All Grades

SAM Level	HR Response (beats/minute)	
	Mean	SD
3	116.25	17.35
5	144.50	24.31
7	158.75	24.30
8	161.62	19.15

Table 3. Percent of MVPA Observed by Grade Level

Grade Level	Mean Percent (%) of MVPA Observed During PE Class Time	
	Mean	SD
Elementary (Grades 3 and 5)	88.50	9.19
Middle School (Grades 6-8)	50.00	30.79
High School (Grades 9-10)	36.50	45.96

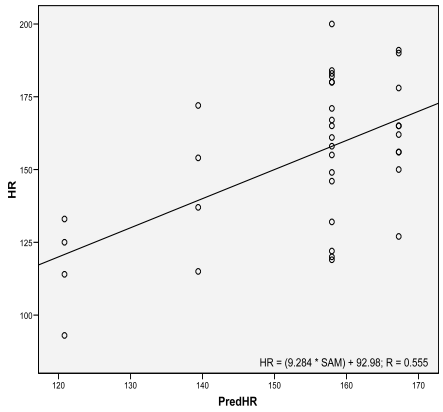

Figure 2. Predicted Validity of SAM Instrument as Compared to Measured HR

DISCUSSION

SAM was found to be a valid measure of field measured MVPA in the observed

classes based upon the positive correlation with student HR monitoring (r=0.555). It was also found to be significantly reliable (r=0.803) in this initial study population. The students studied represented primarily minorities, with low social economic status, and they were considered overweight or obese by their BMI status (see table 1), particularly at the middle school and high school levels (13, 24). Our sample also included a wide maturity range that may have influenced student MVPA performances.

The SAM validity and reliability values of our study were lower than that reported for numerous studies in the literature that have utilized instruments like SOFIT (8, 10). This is likely due to the small sample size in this preliminary study, and the fact that only four categories of MVPA (3, 5, 7 and 8) were observed in the PE classes studied partly as a result of the limited number of PE curricular activities being taught during data collection. It would be expected that the observed validity and reliability of the SAM would improve based upon increasing the sample size in future studies, such that observations reflecting the whole SAM scale could be further verified with objective measures like HR monitoring.

The SAM instrument was effective at classifying the percentage of student MVPA level by grade level (see table 3). We found that students at the elementary level exercised at 81.2% of their HR max for 88.5% of the class time periods observed. Middle school students exercised at 75.8% of their HR max for 50% of the class time, while high school students exercised at 66.1% of HR max, but only had 36.5% of the class time spent in MVPA. Our results are consistent with most studies that have reported higher percentages of student MVPA in PE at the elementary and middle school levels, versus that observed in high schools (4, 5, 9). The lower percentage of student MVPA for PE classes at the middle and high school levels in our study were probably also influenced by the high BMI of those in grades 7-10, which have been reported to be associated with lower levels of physical activity and physical fitness levels in youth (4, 5, 6, 11, 22). Based upon the mean observations from our small sample the elementary and middle schools met the CDC recommendations of having ≥50% of class time devoted to students MVPA, while the high school students did not (23).

We did not evaluate the intra-reliability of the SAM in this preliminary study, which limits the generalizability of the instrument. Future inter-rater reliability studies are planned to improve the validity and reliability coefficients of the instrument. The SAM scale is simple and observers apparently can learn to use the instrument in about one hour of in-service instruction (based on non-published data), however future studies are needed to determine if ease of use is also significantly related to SAM user proficiency.

The SOFIT has become recognized as the "gold standard" for school PE teacher and student behavior related to MVPA (10). The validity coefficients for SOFIT average between R=0.80 to R=0.91 ($p<0.01$ in laboratory studies and between R=0.61 to R=0.89 in field studies). The intra-reliability of SOFIT has been reported to be as high as 0.97 to 0.99 by trained observers (8-10). Other observational instruments like ALT-PE (14), OBSERVA (3), and Bonnie's Fitware (2) are also available for those

interested in evaluating PE in more detail than the SAM instrument allows, and all are valuable tools for data collection concerning PE student activity levels, lesson context, and teacher behavior.

The SAM instrument was developed to be a simpler version of the SOFIT and other traditional teacher observational instruments to provide an accountability measure of student MVPA for professionals interested in evaluating school PE classes. The SAM was designed to provide only basic feedback about PE class instruction and physical activities. Physical activity engagement is one of the main health-related goals of PE and it is needed in order for students to become physically fit and physically skilled. Participation in MVPA during class is highly dependent upon how the PE subject matter is delivered (i.e., lesson context) and the instructor delivering it (i.e., teacher behavior) (8-10). Based upon our preliminary data, the observed SAM values were significantly correlated to student exercise HR responses during PE classes, and allowed simple calculations of group MVPA levels at the elementary, middle, and high school levels in a pilot sample.

Many states have recently mandated PE guidelines recognizing participation in MVPA can help reduce the health risks of students. In Texas for example, Senate Bill (SB) 19 (7) requires students below sixth grade to participate in MVPA daily for at least 30 minutes throughout the school year as part of the district's PE curriculum, or through structured activity during recess. Students in grades six through eight are required to participate in daily PA for at least 30 minutes for at least four semesters during those grade levels (SB 530) (12). If a school district determines, for any particular grade level below sixth grade, that this requirement is impractical due to scheduling concerns or other factors, students in that grade level may participate in MVPA for at least 135 minutes during each school week. Districts that use block scheduling may as an alternative require students to participate in MVPA for at least 225 minutes during each two week school period. Instruments like the SAM may be useful in the future for accessing compliance with MVPA policies like that being promoted in Texas and by the CDC (7, 12, 22).

The strengths of this study include the development of a simple MVPA observational scale that was used at all levels (elementary, middle school, and high school) of PE instruction, and helped evaluate whether PE class time included ≥50% of MVPA. The SAM scale developed is economical for school use and time efficient as compared to other MVPA measurement tools (e.g. accelerometers, global position sensors - GPS, heart rate monitors, and other observational tools like SOFIT).

The study is limited by the use of a small and convenient sample of students from the SAISD and a single observer scoring the SAM instrument. These factors may lower the reliability and validity coefficients of the instrument, and are not generalizable to larger populations. Future studies should include multiple observers with larger sample sizes and feasibility measures that assess the time efficiency of SAM compared to other observational instruments reviewed. It would also be helpful for teachers and evaluators of PE instruction to have a simple electronic data collection

system version (e.g. app) for SAM available to further integrate simple technology into PE classes.

While the use of heart rates to estimate exercise intensity is often used as a criterion measure of MVPA intensity in school PE, it also imposes some weaknesses. Heart rates can be affected by factors such as emotional stress, and current commercially available HR monitors can be challenging to use with approximately 20-25% of individual observations lost to technical errors (e.g. chest belt placement, individual chest variations that can limit HR transmission, etc.) (2-3). Finally, the validity and reliability correlation coefficients of the SAM instrument while significant, were slightly lower than that reported for other observational instruments like SOFIT.

Overall, the results of this preliminary study indicate that the SAM is a user-friendly, economical observation tool to document minutes of MVPA in a small sample of PE classes representing grades 3-10. Initially, it appears that the SAM may have promise as an accountability measure to determine if ≥50% of PE class time is spent in MVPA. Future studies with larger sample sizes are needed to determine if the validity and reliability for SAM can meet or exceed those reported for other PE observational tools currently available.

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REFERENCES

1. Borg G. Psychological bases of physical exertion, Med Sci Sports Exerc 14(5): p. 377-381, 1982.

2. Bonnie's Fitware: Teacher Observation Progam [Online]. Available from: http://shop.pesoftware.com Accessed May 19, 2011.

3. Direct Observation Software Systems: OBSERVA for Physical Education [Online]. Available from: http://www.directobservations.com/Observa.html Accessed May 19, 2011.

4. Fairclough S, Stratton G. Physical activity levels in middle and high school physical education: a review. Ped Exerc Sci 17: p. 217-236, 2005.

5. Jago R, McMurray RG, Bassin S, Bruecker S, Jakicic J, Moe E, et al. (Writing Group on behalf of HEALTHY Study Group) Modifying middle school PE: pilot strategies to increase physical activity, Ped Exerc Sci 21(2): p. 171-185, 2009.

6. Kahn EB, Ramsey LT, Brownson RG, Heath G, Howze EH, Powell KE et al. The effectiveness of interventions to increase physical activity. Am Journal of Prev Med 22(4S): p. 73-107, 2002.

7. Kelder SH, Springer AS, Barroso CS, Sanchez E, Nalini R, Hoelscher DM. Implementation of Texas Senate Bill 19 to increase physical activity in elementary schools. J Public Health Policy 30(Suppl 1): p. S221-S247, 2009.

8. Mckenzie TL, Sallis JF, and Nader PR. *SOFIT:* System for observing fitness instruction time. J Teach Phys Educ 11: p. 195-205, 1991.

9. McKenzie TL, & Kahan D. Physical activity, public health, and elementary schools. Elem School J 108(3): p.171-180, 2008.

10. McKenzie TL. 2009 C.H. McCloy Lecture - Seeing is believing: obeserving Physical activity and its contents. RQES 81(2): p.113-122, 2010.

11. McMurray R, Jago R, Murray T, Bassin S, Volpe S, Moe E, et al. (Writing Group on Behalf of HEALTHY Study Group) Rationale, design and methods of the HEALTHY study physical education intervention component. Int J Obes 33(4): p. S37-S43, 2009.

12. Nelson J. Senate Bill 530: Physical activity requirements for public school students. [Online]. Available from: http://www.nelson.senate.state.tx.us/pr07/p083007a.htm Accessed February 11, 2011

13. Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal, KM. Prevalence of high body index in US children and adolescents, 2007-2008, JAMA 303(3): p. 242-249, 2010.

14. Parker M. Academic learning time-physical education (ALT-PE), 1982 revision. In: Darst, P., Zakrajsek, D., Mancini, V. , editors. Analyzing physical education and sports instruction. Champaign, IL:Human Kinetics; p. 195-205, 1989.

15. Robertson RJ, Goss FL, Bell JA, Dixon CB, Gallagher KI, Lagally KM., et al. Self-regulating cycling using the children's OMNI scale of perceived exertion. Med Sci Sports Exerc 34(7): p. 1168-1175, 2002.

16. Robertson RJ. Perceived Exertion for Practitioners. Champaign, IL: Human Kinetics, 2004.

17. Robertson RJ, Goss FL, Andreacci JL, Dube JJ, Rutkowski JJ, Snee BM, et al. Validation of the children's OMNI RPE scale for stepping exercise. Med Sci Sports Exerc 37(2): p. 290-298, 2005.

18. Siedentop D. National plan for physical activity: education sector, JPAH 6(suppl 2): S168-S180, 2009.

19. Strong WB, Mailina RM, Blimkie CJR, Daniels SR, Dishman RK, Gutin B, et al. Evidence based physical activity for school-age youth, J Pediatr 146: p. 732-737, 2005.

20. Utter AC, Roberston RJ, Nieman DC, Kang J. Children's OMNI scale of perceived exertion: walking/running evaluation, Med Sci Sports Exerc 34(1): p. 139–144, 2002.

21. U.S. Department of Health and Human Services, 2008 Physical Activity Guidelines for Americans [Online]. Washington, D.C. U.S. Department of Health and Human Services; Available from: http://www.health.gov/paguidelines/ Accessed January 20, 2011.

22. U.S. Department of Health and Human Services, 2008 Physical Activity Guidelines Advisory Committee Report [Online]. Washington, D.C. U.S. Department of Health and Human Services; Available from: http://www.health.gov/paguidelines/ Accessed January 20, 2011.

23. U.S. Department of Health and Human Services, Strategies to Improve the Quality of Physical Education [Online]. Washington, D.C. Centers for Disease Control and Prevention; Available From: www.cdc.gov/healthyyouth/pecat/highquality.htm Accessed January 11, 2012.

24. Wang Y, Beydoun MA, Liang L, Caballero B, Kumanyika SK. Will all Americans become overweight or obese? Estimating the progression and cost of the U.S. obesity epidemic. Obesity 16: p. 2323-330, 2008.

25. Weiss MR. "Field of Dreams:" Sport as a context for youth development. RQES 79(4): p. 434-49, 2008.