Effects of Integrating Technology on the Fitness Levels of Elementary Students

Dr. Shelia L. Jackson
Arkansas Tech University
sjackson@atu.edu

Dr. Annette Holeyfield
Arkansas Tech University
aholeyfield@atu.edu

Ms. Jeanie Strasner
Elementary Movement Specialist

Abstract

The purpose of this research was to determine the effects of using technology in physical education classes on the cardiovascular endurance of fourth grade students. Three classes of fourth grade students were randomly assigned to Heart Rate Monitor (HRM), Pedometer, or Control groups and participated in the same physical education activities for 24 weeks. Comparisons on the ½ mile fitness run of the 3 groups were not significantly different from each other ($p = .3580$) at the beginning of the study. There were no significant correlations ($p > 0.05$) between activity levels and mile run times after the 24 weeks. A two-way (Treatment x Gender) ANOVA was used to analyse mile run times after the 24 weeks. The main effect of gender ($p < 0.01$) was significant while the effect of treatment ($p > 0.05$) and the Treatment x Gender interaction ($p > 0.05$) were not.

1. Introduction

The United States Surgeon General [1] emphasized the need for children to become more physically active. As one means to attain that goal, the Surgeon General recommended that well-designed school physical education programs be implemented. The National Association of Sport and Physical Education [2] further proposed content standards for well-designed school physical education programs. One of the standards identified was to achieve and maintain a health-enhancing level of physical fitness. In pursuit of this standard, quality physical education programs have an emphasis on increasing the physical activity of their students.

Researchers have used pedometers, heart rate monitors, and other activity monitors to assess physical activity levels [3, 4, 5, 6, 7, 8, 9, 10, 11]. Consequently, they have also devoted much research to determining whether or not pedometers and/or heart rate monitors are accurate indicators of physical activity in children [12, 13, 14, 15].

Cardon and De Bourdeudhij [12] found a moderate correlation ($r = 0.39$) between pedometer step counts and reported moderate-to-vigorous physical activity (MVPA) over 6 consecutive days. However, Scruggs, Beveridge, Eisenman, Watson, Schultz, and Ransdell [13] reported strong positive correlations between pedometers and MVPA during physical education ($r = 0.74$-0.86). Similarly, Eston, Rowlands, and Ingledew [13] reported strong positive correlations between pedometers and oxygen consumption ($r = 0.92$) and between heart rate monitors and oxygen consumption ($r = 0.80$). Welk, Corbin, and Kampert [16] assessed children's physical activity during a 30-minute physical education class and found the mean within-subject correlation between HR and observed physical activity was 0.79. The results of these and other research studies suggest that both pedometers and heart rate monitors provide accurate and quantifiable evidence of physical activity in children.

Physical educators are increasingly integrating these technologies into their physical education programs [17, 18, 19, 20, 21, 22]. Few studies to date have investigated the effect of providing physical activity feedback using these technologies on the fitness level of children as measured by commonly used tests such as the one mile run found in the Fitnessgram [23]. Further, if providing physical activity feedback through the use of technology does affect fitness, then it would be helpful to know which technology (heart rate monitors or pedometers) affected a greater change. This information, along with an instrument cost comparison, would help physical educators make appropriate choices in their selection and use of technology.

2. Purpose of the Study

The purpose of this research was to determine the effects of using technology (heart rate monitors and pedometers) in physical education classes on the cardiovascular endurance of fourth grade students as measured by the mile run following the protocol of the Fitnessgram [24]. A secondary purpose was to compare the physical activity of males and females during physical education.

3. Methods

3.1. Subjects

Prior to their participation in the study, all subjects obtained written informed consent from his/her guardian. Three classes of fourth grade students (n = 51, males = 22, females = 29) at a rural elementary school in Arkansas were randomly assigned to Heart Rate Monitor (HRM), Pedometer, or Control groups. The HRM and Pedometer groups wore heart rate monitors or pedometers for each of their physical education classes for 24 weeks. The physical education classes met twice a week for 30-minute sessions. All fourth grade classes completed a ½ mile fitness run and attended a presentation concerning the anatomy of the heart and the importance of exercise, proper nutrition, and not smoking in decreasing heart disease before being assigned to groups. The study was approved by the Institutional Review Board.

3.2 Instrumentation

The HRM wore POLAR Electro S810 or LS 110 heart rate monitors. The Pedometer group wore the New Lifestyles Digi-walkers.

3.3 Groups

Using the formula 220-age to calculate maximum heart rate, the target heart rate zone for each child in the HRM group was set between 70 and 85% of her/his maximum heart rate [25]. The HRM group (n = 16, males = 8, females = 8) received feedback from the heart rate monitors by the monitors beeping when the participants were out of their training zone. In addition, they received weekly charts showing them what their heart rates were at 5 s intervals and bar graphs indicating the percentage of time they were in and out of their training zones. A research assistant was present at each of the HRM physical education classes to assist the physical education teacher in putting on the monitors, distributing the charts, and collecting the monitors in order to download the information onto the laboratory computer.

The Pedometer group (n = 16, males = 6, females = 10) noted how many steps they took each class period and wrote the number down on their individual charts. The Control group (n = 19, males = 8, females = 11) participated in the same activities as the other two groups with the same certified elementary physical education teacher but without the feedback from the technologies.

3.4 Statistical Analyses

A one-way ANOVA was run on ½ mile fitness scores taken during the fourth week of school to determine differences among the three groups prior to beginning the study. A t-test for Independent Samples was run on the mean number of steps per minute male and female subjects in the Pedometer group took during the 24-week treatment period. A t-test was also run on the means of the % time in the target heart rate zone data for males and females in the HRM group gathered during the last 10 weeks of treatment. Pearson Product Correlations were run on the mile run scores and the activity levels of the Pedometer and Heart Rate Monitor groups. A two-way (Treatment x Gender) ANOVA was applied to the one mile run scores completed at the end of the 24-week treatment period.

4. Results

Comparisons on the ½ mile fitness run of the 3 groups were not significantly different from each other (p = 0.3580) at the beginning of the study. There were no significant differences (p = 0.3841) between male and female mean steps per minute in the Pedometer group for the 24-week treatment period (see Table 1). Likewise, there were no significant differences (p = 0.4068) between male and female mean % time in target zone in the HRM group for the last 10 weeks of treatment (see Table 1). In addition, the correlations between the mile run scores and activity levels of the Pedometer (r = 0.4659, p = 0.1269) and the HRM (r = 0.3938, p = 0.2053) groups were not significant.

A two-way (Treatment x Gender) ANOVA was used to analyze mile run times following the 24 weeks of treatment. The main effect of gender (p = 0.0016) was significant while the effect of treatment (p = 0.2704) and the Treatment x Gender interaction (p = 0.7800) were not.

Means and standard deviations of each group by gender are reported in Table 2. Post-hoc tests using a Scheffe multiple comparison tests revealed significant differences between the Male Control group and the three female groups and the Male HRM group and the three female groups (see Table 3). However, there were no significant differences between the Male Pedometer group and the female groups.

Table 1. Means and Standard Deviations of Physical Activity

Group	N	Mean	SD
Pedometer (spm)			
Males	**6**	**51.3567**	**9.1346**
Females	**10**	**52.4640**	**11.4944**
HRM (bpm)			
Males	**8**	**30.5438**	**10.4472**
Females	**8**	**29.1912**	**12.0101**

Note: HRM = Heart Rate Monitor; spm = steps per minute; bpm = beats per minute

Table 2: Means and Standard Deviations of Times on Mile Run by Group

Group	N	M	SD
Male HRM	**7**	**10.1500**	**2.1240**
Male Control	**4**	**10.3825**	**1.4490**
Male Pedometer	**5**	**12.1720**	**1.7715**
Female HRM	**6**	**12.9500**	**2.3818**
Female Pedometer	**7**	**13.0757**	**2.0532**
Female Control	**10**	**13.2970**	**2.0818**

Note: HRM = Heart Rate Monitor.

5. Discussion

Most of the literature integrating technologies such as heart rate monitors and pedometers into the physical education setting has focused on the activity level and not the fitness level of children [12, 13, 14, 15]. Many researchers have reported that males exhibit significantly greater vigorous activity than females [12, 26, 27, 28, 29]. The results of this study differ in that there were no significant differences between males and females' activity levels in either the HRM or the Pedometer group. One possibility for the difference between the findings of this study versus those in previous research might be the length of time in which the data were gathered. Also, most of the previous studies had the children wear the monitors during unstructured times such as home and recess as well as during physical education.

Trost, Pate, Dowda, Saunders, Ward, and Felton [30] found males to have greater physical fitness than females. The results of this study are in agreement with Trost et al in that males were significantly faster than females on the one mile run.

Although the results of this research did not find any significant differences among the three treatments, it was interesting to note that when looking at the differences in the times between males and females, the female groups using technology did have faster mean times than the female control group. That was not the case, however, for the male groups. The male pedometer group had the slowest times of the male groups and was not significantly faster than the females. Thus, the significant differences between males and females lessened as the females were provided with more information about their performances and/or were given more attention. This is in agreement with the meta-analysis of pedometer-based physical activity interventions conducted by Minsoo, Marshall, Barreira, and Jin-Oh Lee [31] who found technology using pedometers had a greater effect with females in increasing participation in physical activity.

The Hawthorne Effect might have attributed to the two technology female groups performing better than the female control group. The HRM groups did receive additional attention in that another person was at every one of their classes to help put the heart rate monitor straps on, collect the monitors, and give them the weekly charts. Although the female pedometer group did not have an additional person in their physical education classes, they may have tried "harder" in order to please their teacher. If this, however, was the case, why did it not happen with the male pedometer group?

When looking at the original research regarding the Hawthorne Effect, a criticism of the original three studies was that they did not take into account gender differences. For the most part, the subjects from the Western Electric assembly line were young women, and the researchers were young males attending Harvard [32]. If the Hawthorne Effect does have a greater impact on females than males, it might also contribute to the differences found in this study and the literature regarding physical activity and gender. Additional research looking at the Hawthorne Effect with regard to gender might prove to be valuable in providing better physical education experiences to females.

6. Conclusion

The use of heart rate monitor and pedometer technology did not have an effect on the fitness levels of fourth grade students as measured by the one mile run, and male and female activity levels during physical education did not differ.

7. References

[1] United States Surgeon General, United States Department of Health & Human Services, *A report of the Surgeon General*, United States Government Printing Office, Washington, DC, 1996.

[2] Rink, J. (1995). *Moving into the future-National standards for physical education: A guide to content and assessment*, National Association for Sport and Physical Education, Reston, VA. 1995.

[3] Bassett, D. R., Jr., Cureton, A. L., and Ainsworth, B. E., “Measurement of daily walking distnace-questionnaire versus pedometer,” *Medicine & Science in Sports & Exercise, 32*(5), 2000, pp. 1018-1023.

[4] Freedson, P. S., and Miller, K., “Objective monitoring of physical activity using motion sensors and heart rate,” *Research Quarterly for Exercise and Sport, 71*(2), 2000, pp. 21-29.

[5] Le Masurier, G. C., & Tudor-Locke, C., “Comparison of pedometer and accelerometer accuracy under controlled conditions,” *Medicine & Science in Sports & Exercise, 35*(5), 2003, pp. 867-871.

[6] Strand, B. and Reeder, S., “Using heart rate monitors in research on fitness levels of children in physical education,” *Journal of Teaching in Physical Education, 12*, 1993, 215-220.

[7] Talbot, L. A., Metter, E. J., Morrell, C.H., Frick, K. D., Weinstein, A. A., and Fleg, J. L., “A pedometer-based intervention to improve physical activity, fitness, and coronary heart disease risk in National Guard personnel,” *Military Medicine, 176*(5), 2011, pp. 592-600.

[8] Tudor-Locke, C., “A preliminary study to determine instrument responsiveness to change with a walking program: Physical activity logs versus pedometers,” *Research Quarterly for Exercise and Sport, 72*(3), 2001, pp. 288-292.

[9] Tudor-Locke, C., Ainsworth, B. E., Thompson, R. W., and Matthews, C. E., “Comparison of pedometer and accelerometer measures of free-living physical activity,” *Medicine & Science in Sports & Exercise, 34*(12), 2002, pp. 2045-2051.

[10] Welk, G. J., and Corbin, C. B., “The validity of the Tritrac-R3D activity monitor for the assessment of physical activity in children,” *Research Quarterly for Exercise and Sport, 66*(3), 1995, pp. 202-209.

[11] Welk, G. J., Differding, J. A., Thompson, R. W., Blair, S. N., Dziura, J., and Hart, P.“The untility of the Digi-Walker step counter to assess daily physical activity patterns,” *Medicine & Science in Sports & Exercise, 32*(9), 2000, pp. 481-488.

[12] Cardon, G. and De Bourdeaudhuij, I., “A pilot study comparing pedometer counts with reported physical activity in elementary schoolchildren,” *Pediatric Exercise Science, 16*, 2004, pp. 355-367.

[13] Eston, R.G., Rowlands, A.V., and Ingledew, D.K., “Validity of heart rate, pedometry, and accelerometry for predicting the energy cost of children’s activities,” *Journal of Applied Physiology*, 84, 1998, pp. 362-371.

[14] Scruggs, P. W., Beveridge, S. K., Eisenman, P. A., Watson, D. L., Shultz, B. B., and Ransdell, L. B., "Quantifying physical activity via pedometry in elementary physical education," *Medicine and Science in Sports and Exercise, 35*(6), 2003, pp. 1065-1071.

[15] Trost, S. G., "Objective measurement of physical activity in youth: Current issues, future direction," *Exercise and Sport Sciences Reviews, 29*(1), 2001, pp. 32-36.

[16] Welk, G. J., Corbin, C. B., and Kampert, J. B., "The validity of the Tritrac-R3D activity monitor for the assessment of physical activity: II. Temporal relationships among objective assessments," *Research Quarterly for Exercise and Sport, 69*(4), 1998, pp. 395-400.

[17] Benham-Deal, T., and Deal, L. O., "Heart to heart: Using heart rate telemetry to measure physical education outcomes," *Journal of Physical Education, Recreation & Dance, 66*(3), 1995, pp. 30-35.

[18] Hardman, C.A., Horne, P.J., and Lowe, C.F., "Effects of rewards, peer-modelling and pedometer targets on children's physical activity: A school-based intervention study," *Psychology & Health, 26*(1), 2011, pp. 3-21.

[19] Hinson, C., "Pulse power-A heart physiology program for children," *Journal of Physical Education, Recreation & Dance, 65*(1), 1994, pp. 62-68.

[20] Lee, L., Kuo, Y., Fanaw, D., Perng, S., and Juang, I., "The effect of an intervention combining self-efficacy theory and pedometers on promoting physical activity among adolescents," *Journal of Clinical Nursing, 21*(7/8), 2014, pp. 914-922.

[21] Lieberman, L. J., Stuart, M. E., Hand, K., and Robinson, B., "An investigation of the motivational effects of talking pedometers among children with visual impairments and deaf-blindness," *Journal of Visual Impairment & Blindness, 100*(12), 2006, pp. 726-736.

[22] Strand, B., and Mathesius, P. "Physical education with a heartbeat," *Journal of Physical Education, Recreation & Dance, 66*(9), 1995, pp. 64-68.

[23] American Alliance for Health, Physical Education, Recreation and Dance,"Fitnessgram (Part 2)," *Strategies, 18*(3), 2005, pp. 35-38.

[24] The Cooper Institute, *Fitnessgram /Activitygram: Test administration manual* (4th ed.). Human Kinetics, Champaign, IL, 2007.

[25] Kirkpatrick, B. and Burton, H.B., *Lessons from the heart: Individualizing physical education with heart rate monitors,* Human Kinetics, Champaign, IL, 1997.

[26] Myers, L., Strikmiller, P.K., Webber, L.S., and Berenson, G.S., "Physical and sedentary activity in school children grades 5-8: the Bogalusa Heart Study," *Medicine and Science in Sports and Exercise, 28*, 1996, pp. 852-859.

[27] Tudor-Locke, C. E. and Myers, A. M., "Methodological consideration for researchers and practitioners using pedometers to measure physical (ambulatory) activity," *Research Quarterly for Exercise and Sport, 72*(1), 2001, pp. 1-21.

[28] Vincent, S.D. & Pangrazi, R.P., "An examination of the activity patterns of elementary school children," *Pediatric Exercise Science, 14*, 2002, pp. 432-441.

[29] Wilde, B. E., Corbin. C. B., and Le Masurier, G. C., "Free-living pedometer step counts of high school students," *Pediatric Exercise Science, 16*, 2004, pp. 44-53.

[30] Trost, S. G., Pate, R. R., Dowda, M., Saunders, R., Ward, D. S., and Felton, G., "Gender differences in physical activity and determinants of physical activity in rural fifth grade children," *Journal of School Health, 66*(4), 1996, pp. 145-150.

[31] Minsoo K., Marshall, S. J., Barreira, T. V., and Jin-Oh Lee., "Effect of pedometer-based physical activity interventions: A meta-analysis," *Research Quarterly for Exercise & Sport, 80*(3)3, 2009, pp. 648-655.

[32] Brannigan, A. and Swerman, W., 'The real "Hawthorne Effect,"' *Society, 38*(2), 2001, pp. 55-60.