Application Research of Physical Activity Measurement Tool Compared with Traditional Observation Method in Exercise Density of Physical Education Class

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Abstract. This paper takes the cricket course of Tsinghua University as an example to study how to quantitatively monitor the exercise density of physical education class through the three-axis accelerometer physical activity measurement tool, and obtain the calculation formula of effective exercise density in physical education class. Compare physical activity objective measurement method with physical education teachers’ traditional subjective observation method to find out the differences between these two measurement methods of exercise density in physical education classes. It will provide a reference for the exercise density evaluation in physical education classes and the physical activity monitoring of the students.

Introduction

In recent years, many researchers in different countries have not stopped studying the revolution and innovation of physical education class content, PE teacher training, PE teaching materials and teaching methods. However, the quality of physical education class should be mainly implemented in the actual effective health benefits of students in class. Many school sports researchers often use the "exercise density" indicator as an important factor to measure the quality of PE class. The exercise density in a PE class means “In the process of a complete PE class, the ratio of the actual exercise time of each student individual to the whole PE class time” [1]. It is an important indicator for evaluating the quality of a PE class and it is also a monitoring indicator for evaluating a student individual’s exercise participation and completion in a PE class [2]. Only by accurately monitoring and understanding this indicator, can the quality of PE class and the physical health of students group improve [3]. With the advancement of sports monitoring tools, researchers and school-based policy makers need to make new breakthroughs in this field. This paper takes the cricket course of Tsinghua University as an example to study the advantages of three-axis accelerometer physical activity measurement tools on the exercise density monitoring in PE class.

Research Subjects and Methods

Research Subjects

Forty male undergraduate students of Tsinghua University (age: 20±1.3 years old, height: 174.5±5.60cm weight: 82.7±16.76kg).

Research Methods

Literature Method. Through searching in CNKI China Knowledge Network, EBSCO, Web of Science and other databases; Tsinghua University Humanities and Social Sciences Library, Beijing Sports University Library literature, collect and summarize relevant literature research on student group exercise density in PE class.
Observation Method. Observe the teaching content and teaching design of PE teacher in the cricket class; and the physical activity performance, physiological characteristics and physical participation of every student in cricket class. Obtain the data about exercise density in this class through the intuitionistic observation.

The requirements of the exercise density through observation method: According to the table 1, observe and record the actual exercise time in the class and the whole class time. And then analyze the exercise density in different parts of this class and the average exercise density in the whole class.

<table>
<thead>
<tr>
<th>The parts in PE class</th>
<th>Action demonstration by teacher [min]</th>
<th>Exercise time [min]</th>
<th>Break interval [min]</th>
<th>Total time [min]</th>
<th>Exercise density</th>
<th>Average exercise density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Game time</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Norm: In the process of cricket movement measurement, all processes should be standardized and unified as much as possible. Cricket class is divided into a practice part and a game part. In the practice part, after the teacher has finished the action demonstration and explanation, the subjects are required to start the exercise and take a break at the same time. In the game part, the subjects are required to form different teams to perform the cricket game, and similarly, start time, end time and break interval are also uniform.

Experiment Method. Using the Actigraph GT 3X+ three-axis accelerometer to measure the physical activity intensity and time of every subject in this PE class. According to the CPM (Count Per Minute) data of this accelerometer, calculate every subject’s MVPA (Moderate Vigorous Physical Activity) time and acquire every student’s exercise density in both different parts and the whole class.

Interview Method. Interview some PE class teachers, school sports researchers and specialists to understand the impact of different PE class content arrangements on students’ exercise density and exercise load.

Mathematical Statistics Method. Statistical analysis of the student's exercise density data collected in the experiment was performed by IBM SPSS Statistics 20 and EXCEL 2010.

Research Contents and Results

Analysis of Exercise Density Based on Traditional Subjective Observation Method

<table>
<thead>
<tr>
<th>The parts in PE class</th>
<th>Demonstration+ Warm up [min]</th>
<th>Exercise time [min]</th>
<th>Break interval [min]</th>
<th>Total time [min]</th>
<th>Exercise density</th>
<th>Average exercise density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice time</td>
<td>10+10</td>
<td>20</td>
<td>5</td>
<td>40</td>
<td>0.75</td>
<td>0.777</td>
</tr>
<tr>
<td>Game time</td>
<td>-</td>
<td>40</td>
<td>5</td>
<td>50</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 2, based on traditional subjective observation method, there are several results:

Practice part:
Exercise density = (warm-up time + exercise time in practice part) / total practice part time = (10+20)/40 = 0.75

Game part:
Exercise density = exercise time in game part / total game part time = 40/50 = 0.8
Average density = (warm-up time + exercise time in practice part + exercise time in practice part) / total time = (10+20+40)/90 = 70/90 = 0.777

Analysis of Exercise Density Based on Physical Activity Objective Measurement Method

Table 3. The Analysis of Exercise Density Based on Physical Activity Objective Measurement Method.

<table>
<thead>
<tr>
<th>The parts in PE class</th>
<th>Warm up [min]</th>
<th>Effective exercise time [min]</th>
<th>Break interval [min]</th>
<th>Total time [min]</th>
<th>Exercise density</th>
<th>Average exercise density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice time</td>
<td>5.60±0.91</td>
<td>9.67±1.05</td>
<td>5</td>
<td>40</td>
<td>0.38±0.04</td>
<td>0.777</td>
</tr>
<tr>
<td>Game time</td>
<td>-</td>
<td>29.93±2.71</td>
<td>5</td>
<td>50</td>
<td>0.60±0.05</td>
<td></td>
</tr>
</tbody>
</table>

According to the Freedson Adult VM3 (2011) model [4], the physical activity intensity can be divided by CPM indicator. The model uses VM (Axis1, Axis2 and Axis3) CPM data, which is the CPM of the Vector Magnitude (SQRT[(Axis 1)^2 + (Axis 2)^2 + (Axis 3)^2 ] ) count value, as the original data index. The standard is: 0-2690 CPM is for LPA (Light-intensity Physical Activity), 2691-6166 CPM is for MPA (Moderate-intensity Physical Activity), 6167-9642 CPM is for VPA (Vigorous-intensity Physical Activity), 9643-∞ CPM is for VVPA (Very Vigorous-intensity Physical Activity). MVPA includes MPA, VPA and VVPA.

As shown in Table 3, based on traditional subjective observation method, there are several results:

Practice part:
Effective exercise time = the MVPA time in practice part = 9.67±1.05 min
Effective exercise density = the MVPA time in practice part/ total practice part time = 0.38±0.04

Game part:
Effective exercise time = the MVPA time in game part = 29.93±2.71 min
Effective exercise density = the MVPA time in game part/ total game part time = 0.60±0.05

Average density = (warm-up time + exercise time in practice part + exercise time in practice part) / total time = 0.50±0.04

The Comparison between Physical Activity Objective Measurement Method and Traditional Subjective Observation Method

![Figure 1. The Comparison of Effective Exercise Time between Physical Activity Measurement Method and Traditional Observation Method.](image_url)

The Comparison of Effective Exercise Time between Physical Activity Measurement Method and Traditional Observation Method. As Fig. 1 shows, the warm-up time, effective exercise time in practice part and the effective exercise time in game part based on observation method is higher than these based on physical activity measurement method. The warm up time...
based on physical activity measurement method (5.6min) equals about 56% of that based on observation method (10min). The effective exercise time in practice part based on physical activity measurement method (9.67min) equals nearly 48.35% of that based on observation method (20min). The effective exercise time in game part based on physical activity measurement method (29.93min) equals 74.83% of that based on observation method (40min).

![Figure 2. The Comparison of Exercise Density between Physical Activity Measurement Method and Traditional Observation Method.](image)

The Comparison of Exercise Density between Physical Activity Measurement Method and Traditional Observation Method. It can be seen from Fig. 2 that the exercise density in practice part, the exercise density in game part and the average density measured by observation method are all higher than those measured by physical activity measurement method. The exercise density in practice part calculated by physical activity measurement method (0.38) equals about 50.67% of that calculated by observation method (0.75). The exercise density in game part calculated by physical activity measurement method (0.60) equals nearly 75% of that calculated by observation method (0.80). The average exercise density calculated by physical activity measurement method (0.50) equals about 64.1% of that calculated by observation method (0.78).

The Difference and Connection of the Exercise Density Based on These Two Different Measurement Methods

<table>
<thead>
<tr>
<th>Warm up</th>
<th>Effective exercise time in practice part</th>
<th>Effective exercise time in game part</th>
<th>Exercise density in practice part</th>
<th>Exercise density in game part</th>
<th>Average exercise density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation method</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Physical activity measurement method</td>
<td>56%</td>
<td>48.35%</td>
<td>74.83%</td>
<td>50.67%</td>
<td>75%</td>
</tr>
</tbody>
</table>

As shown in Table 4, if we regard the exercise density data based on observation method as a control group data, the exercise density data based on physical activity measurement method will be thought as an experimental group data. And then we can get the percentage of the exercise density data based on physical activity measurement method accounted for that based on observation method.

When it comes to effective exercise time and exercise density in practice part, we can see large differences between these two measurement methods, which are 48.35% and 50.67% respectively.
It indicates that the exercise density monitoring in real practice environment of PE class by traditional observation method overestimates the physical activity of students. And the exercise in practice part doesn’t make full benefits for students to promote MVPA to get health effect. PE teachers should focus more on the MVPA monitoring in this part.

The exercise time and exercise density in game part measured by these two methods are a little bit close, which are 74.83% and 75% respectively. It means that game part in a PE class can fully mobilize the enthusiasm of all students at the same time and promote major muscle groups to conduct MVPA, and it also indicates traditional observation method by PE teacher overestimate the exercise density in this part.

In terms of average density, the data measured by physical activity measurement method is only 64.10% of that by observation method. This means the subjective observation by PE teacher are not accurate enough to reflect the real exercise intensity of students. Even the difference is considerable large.

Research Conclusions

1. In terms of light-moderate intensity practice part in a PE class, the exercise density measured by observation method can’t reflect the effectiveness of the exercise density.
2. In terms of moderate-vigorous intensity game part in a PE class, the exercise density measured by observation method are close to that measured by three-axis accelerometer physical activity measurement method.

Summary and Suggestions

The essence of physical education class is the various activities based on various exercises, and the learning results of sports knowledge and motor skills are performed through the physical movement of students [5]. In past PE classes, schools and teachers only focused on imparting motor knowledge and skills, and did not care whether these knowledge skills could be effectively translated into the physical activity level or physical health level of the student group. Nowadays, many foreign scholars believe that physical education should focus more on whether the student group can improve their physical activity level in class, especially MVPA [6,7]. I believe that the exercise density should be the ratio of the effective exercise time of the individual to the total PE class time. The so-called effective exercise time is the exercise time that can produce certain health benefits through physical activities and movements. Therefore, the monitoring of exercise density should not only rely on the traditional observation method to accumulate the exercise time, but should add the concept of “effective physical activity intensity” to the understanding of “exercise density”. World Health Organization recommend that children and adolescents should conduct at least 60min MVPA every day [8]. And adults need 150-300 minutes of MVPA every week, which will have a beneficial effect on various factors of physical health [4]. Therefore, whether for students in primary school and middle school who are adolescents, or college students who are already adults, both of them should pay more attention to effective MVPA in PE classes.

For the monitoring of MVPA, objective physical activity measurement tools should be used instead of subjective observation by teachers. In recent years, the three-axis accelerometer represented by Actigraph has become a common physical activity monitoring tool in the laboratory and research [9], I suggest that its principle design should be applied to more physical education practice. The advantages are: 1. The MVPA calculation formula is more accurate and objective; 2. The PE teacher can focus more on the motor guidance and promoting physical activity, rather than observing and calculation exercise density; 3. Every student can keep track of their physical activity level and this monitoring tool can encourage students to engage in more physical activity.
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References