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Application of Smart Wristband to Monitor Exercise Intensity and Safety in Physical Education

Ye Wang and Jingmin Liu

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Ye WANG
Department of Sports Science and Physical Education
Tsinghua University
Beijing, China
wangye@tsinghua.edu.cn

Jingmin LIU
Department of Sports Science and Physical Education
Tsinghua University
Beijing, China
ljm_th@tsinghua.edu.cn

Abstract*—In order to monitor the students' quantity and intensity of exercise in real time in physical education, a smart wristband was developed to measure the heart rate and physical activity simultaneously. Method: 188 Chinese secondary school students (101 males and 87 females) were tested in the real-time with wristbands in physical education class. Result: the average heart rate was 125.5 beats/min for boys and 122.2 beats /min for girls; the average HR_{max} was 178.6 beats/min for boys and 171.4 beats/min for girls, which were kept in the safe range. The average exercise time was 56.3%, the average exercise load was 65.6%, and the total physical activity CPM (counts per minute) was 389.3. Conclusions: smart wristband can not only accurately measure physical activity, exercise load and heart rate of students in physical education courses, but also evaluate physical education and control exercise intensity. Moreover, it can warn individual students whose heart rate is out of safe range to make sure the safety during exercise.

Keywords—Physical Education, Smart Wristband, Exercise Heart Rate, Physical Activity

I. INTRODUCTION

Teachers arrange courses for students according to the teaching plan in physical education. However, is the exercise intensity suitable for all students in the physical education courses? Does it reach the goal of exercise? Or is there a potential danger for individual students over-training. If teachers can get the information mentioned above accurately, they will fulfill the teaching task better and will give students individualize instruction to achieve the goal of improving physical health in the physical education courses.

Exercise intensity and safety monitoring of students in physical education can be fulfilled by measuring physical activities and heart rate. Physical activity refers to any bodily movement produced by skeletal muscle that results in energy consumption[1].At present ,the international physical activity questionnaire (IPAQ), global physical activity questionnaire (GPAQ), and minnesota leisure time physical activity questionnaire (MLTPAQ) are widely used to evaluate physical activity[2]. But the subjective questionnaire survey is inferior to the monitoring of physical activity, activity count, energy consumption and metabolic equivalent by sensors and other technological methods and more accurate objective investigation method[3]. Heart rate refers to the number of heart beats per minute, which is the basic index to reflect the heart state and working ability, and also the objective reflection of the intensity of physical activity. The heart rate is consistent with the pulse which can be measured instead of heart rate during exercise. Pulse measurement includes pressure method, ECG method and photoelectric volume method. Photoelectric volume method refers to a test method which is obtained heart rate by detecting the change of the blood volume in a micro-artery or capillary. The basic theory is to irradiate the body surface with the beam of fixed intensity and measure the light intensity absorbed by the human body through the receiving sensor. Since the light intensity received is proportional to the volume of the vessel in the irradiated region, and the blood

vessel volume changes regularly along with the change of each heart rate as same as the heart rate. Therefore, the change of the optical signal received by the receiving sensor can be converted into an electrical signal, and then the heart rate data can be obtained on the equipment. Wearable devices, such as smart wristband, which can measure both physical activity and real-time pulse are rare in the practice research. Therefore, it is essential to develop a smart wristband which can monitor physical activity and heart rate in exercise. It is of practical significance to improve the teaching quality of physical education.

II. METHODS

A. Structure and function of smart wristband

The design of smart wristband includes hardware and software. The smart wristband contains piezoelectric sensor which removes PPG noise by multi-wavelength and unique signal processing algorithms. It can resist the interference to monitor. Its anti-jamming ability is stronger. Two green wavelengths of light-emitting LED and a photosensitive sensor are used to sense changes in the light transmittance of the blood in the arm as it pulsates, and the change of the intensity of the light field is tested to convert into pulses. PPG signal can be compensated better by increasing the brightness and sampling rate of LED. The algorithm will recognize different skin color, compensate ambient light and other processing besides motion cancellation. There is no need to use the chest belt when measure heart rate by green light photoelectricity, which overcomes the inconvenient wearing problem of chest belt. At the same time, the wristband display screen provides real-time heart rate feedback. APP in mobile terminal computers or IPAD, can continuously measure the heart rate, calculate the average heart rate, record the maximum heart rate, set the alarm range of the heart rate, in order to conduct the measurement and safety control on real-time heart rate. The three-axis accelerometer in the wristband can measure and capture acceleration in the direction of three axes of motion. Physical activity measurements are presented in the form of CPM "counts per minute" data. According to CPM data, combined with different models, the individual's amount and intensity of physical activity and energy consumption can be evaluated.

B. Testing subjects and method

The exercise intensity of 188 secondary school students in Shanghai and Hunan in China were tested in their physical education class. The age of testing samples was 15.6±0.9yrs，including 101 males，height 168.4±4.5cm， weight 58.5±4.5kg; 87 females， height 161.0±4.3cm ， weight 46.3±2.4kg. Fitbeans smart wristband was worn on the left carpal joint 2cm above the transverse stria. Test indicator: HR accuracy is ±1 beat/sec, sampling frequency is 60/min; CPM measuring accuracy is ±1 beat/sec, sampling frequency is 60/min; Physical education class lasts 40 minutes.; Exercise time ratio= (warm-up time + exercise time)/total class time*100%; Exercise load =time of exercise HR>60% HR_{max}/exercise time *100%; HR_{max}=220-age.

III. RESULTS

A. Exercise intensity

The average exercise time ratio of all students involved in the test was 56.3% in physical education class. It was at medium level. It can be explained that the exercise time arranged by teachers for students was not much comparing the total time in class. The average exercise load of all students is 65.6%，the lowest is 31.0%，the highest is 100%. It is indicated that the ratio of exercise time was at the middle and superior level and achieved the exercise effect of physical education class. The average HR of boy was 125 beats/min, 122 beats/min for girls. The average HR_{max} of male students was 178.6 beats/min, 171.4 beats/min for female students, which was within the safety range. (Table 1)。

Table 1 Heart Rate And Exercise Value In Physical Education Class

Sex	Average exercise HR (beat/min)	HR_{min} (beat/min)	HR_{max} (beat/min)	Exercise time ratio (%)	Exercise load (%)
Male students	125.5±15.7 83～169	64.7±27.9 40～144	178.6±17.4 97～209	58.5±5.4 21～70	64.9±21.6 31～99

Female students	122.2±16.9 85～161	74.8±27.8 39～143	171.4±22.9 106～206	53.1±5.9 21～69	66.4±20.3 31～100

B. Results and analysis of physical activity

The average CPM of all students was 389.7 measured by smart wristband in 40 minutes physical education class, variation rang was 97-969. CPM can reflect the amount of the exercise in the physical education class. CPM of different students can reflect the amount of their physical activity in the same teaching intensity. According to the individual CPM, it showed that the physical activity of some students was significantly more than other students, while some students' overall physical activity whose amplitude and frequency of motion were obviously was less than others. (See *Table 2*).

Table 2 Physical Activity Counts in Physical Education

CPM	male	female	all
mean± standard	423.0±127.8	349.5±151.2	389.7±143.5
range	97～969	117～785	97～969

When measuring exercise heart rate and physical activity by smart wristband in the physical education class, it had found that some individual students' HR was beyond safety range, that is to say, their MHR was above 90%. By comparing with these students, they had obvious over-exercise features that the boy was sweating a lot and shortness of breath. Teachers can pay close attention to these students and remind them to control the exercise intensity to prevent the heart rate from rising too quickly and ensure the exercise in safety.

IV. CONCLUSIONS

The smart wristband can help teachers monitor students' exercise intensity better by measuring students' HR and evaluating physical activity in physical education. It also can monitor exercise safety and can obviously improve proper arrangement of exercise intensity and controllability of exercise safety of students in physical education.

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