Applied Ergonomics 46 (2015) 218–223

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Energy expenditure at work in physical education teachers

François Trudeau*, Louis Laurencelle, Claude Lajoie

Département des sciences de l'activité physique, Université du Québec à Trois-Rivières, Canada

ARTICLE INFO

Article history:
Received 9 April 2014
Accepted 6 August 2014
Available online 27 August 2014

Keywords:
Oxygen consumption
Heart rate
Teaching

ABSTRACT

The objective of this study was to quantify work energy expenditure (EE) in physical education (PE) teachers. Sixty-four (64) physical educators (49 men, 15 women) had their individualized linear function between heart rate (HR) and oxygen consumption measured by laboratory testing. HR was then recorded on 2 different days at work to estimate EE, correlated with a diary of daily tasks. Average absolute EE was low-to-moderate (2.7 ± 1.4 to 4.6 ± 2.5 kcal·min^{-1}) and low when expressed in relative values (15.3 ± 6.1% to 24.8 ± 7.6% of VO_2max). However, these physical educators often reached very high intensities (from 7.5 ± 7.9% to 23.8 ± 22.3% of work time at 100 bpm and more). PE teaching requires a light-to-moderate EE with more intense periods of physical activity. The variety of tasks performed (office work, supervision and monitoring, mixed participation and active participation) significantly influenced EE.

1. Introduction

Physical educators are a special category of teachers. Sandmark et al. (1999) suggested that workload is heavy among physical education (PE) teachers. In fact, some authors claim that the occupational requirements of PE teaching compare to those of forestry, agricultural and construction workers (Skiold, 1999). Such heavy workloads have also been associated with a high rate of musculoskeletal dysfunction and injuries among PE teachers (Lemoyne et al., 2007; Sandmark, 2000). Indeed, in a qualitative survey of Quebec PE teachers, few perceived themselves as being able to actively continue their profession until retirement age (Bizet et al., 2010).

Energy expenditure (EE) among PE teachers was not assessed quantitatively in previous studies. Sandmark et al. (1999) analyzed their work tasks by direct observation. High physical load may be caused by equipment handling, by supporting the load of students' weight in certain situations, by prolonged standing, stress and repetitive or sudden movements (Sandmark et al., 1999). Not only do they have to lift students in parades for gymnastics or psychomotor learning, often in awkward and difficult positions, but they are also exposed to additional horizontal shear forces. Ultrafast, dynamic forces can inflict large and sudden mechanical loading with increased risk of musculoskeletal injuries or fractures. Heart rate (HR) was recorded per daily work duration and was on average above 100 beats per minutes (bpm) for 42% of the work period in women, and 25% in men (Sandmark et al., 1999). Activities which generated the highest HRs were warm-ups, aerobic exercises, dance and circuit training. In these activities, teachers usually participated and helped students through demonstrations. Participation in warm-ups, aerobic exercise and support of students in gym class generated peak HRs of 150 bpm or more (Sandmark et al., 1999). However, the literature tells us little about the relative workload that these teachers must face. HR was not converted into EE values. Indeed, to the best of our knowledge, no study has investigated the average percentages of maximum metabolic capacity (max) that physical educators must endure every workday.

The main purpose of this research is to quantify EE in PE teachers in their work environment. We also compare EE across various conditions (teaching levels, types of tasks performed, gender, age, and years of experience).

2. Methods

2.1. Participants

Sixty-four (64) PE teachers from the south central part of Quebec (Mauricie, Bois-Francs, and Quebec City), involved at different levels of education, volunteered to participate in this

* Corresponding author. Département des sciences de l'activité physique, Université du Québec à Trois-Rivières, 3351, boul. des Forges, C.P. 500, Trois-Rivières, Québec G9A 5H7, Canada. Tel.: +1 819 376 5011x3767; fax: +1 819 376 5092.

E-mail addresses: Francois.Trudeau@uqtr.ca (F. Trudeau), Louis.Laurencelle@uqtr.ca (L. Laurencelle), Claude.Lajoie@uqtr.ca (C. Lajoie).

http://dx.doi.org/10.1016/j.apergo.2014.08.010

study. A special feature in Quebec is that across all school levels (from primary to pre-university), PE is taught by specialists. Our sample included 22 teachers from primary schools (18 males and 4 females), 32 from secondary schools (24 males and 8 females), and 10 from colleges, i.e. pre-university (7 males and 3 females). Table 1 gives details of sample composition. The project received prior approval from the institutional Human Research Ethics Committee at the Université du Québec à Trois-Rivières. Each eligible participant visited once in the laboratory, and data were collected twice in the field. Informed signed consent was obtained in the laboratory session, and health status was profiled according to procedures for risk stratification of the Canadian Society for Exercise Physiology (CSEP, 2003). Anthropometric and fitness variables were measured. Oxygen consumption/HR regression equation was established during progressively maximal treadmill testing, detailed later in the text. During the laboratory visit, participants identified 2 workdays for data collection in the field. During these workdays, they each wore a HR monitor with built-in memory and an accelerometer to quantify movement counts.

2.2. Tests and measurements

At the beginning of the laboratory session, blood pressure (BP) was monitored by sphygmomanometer (Tycos Healthometer, Mansfield, Mass., USA) on 2 occasions separated by 10 min, as stipulated by the Canadian Society for Exercise Physiology (2003). Anthropometric measurements were undertaken, as directed by the CSEP (2003). The weight of study participants was measured with a beam balance (Detectomedic, Detecto Scales, Inc., Brooklyn, NY, USA). Participant height was noted by stadiometer (Healthometer, Bridgeview, IL, USA), and waist circumference (WC), by tape. Finally, skinfold thickness was measured on the right side of the body (CSEP, 2003) with a Harpenden adipometer (John Bull British Indicators, UK).

2.2.1. Muscle capacities

We quantified back muscle (modified Sorensen test) and abdominal muscle (sit and reach) endurance, leg power (vertical jump), elbow extensor/shoulder flexor endurance, hip flexibility and handgrip strength (CSEP, 2003).

2.2.2. EE estimation

EE was computed on the basis of interpolation of regression built with the relationship between HR and oxygen consumption (VO_2), by maximal incremental laboratory testing. To determine this relationship, we calculated a regression equation specific to each subject, and then measured HR at the worksite. The corresponding predicted value of VO_2 was then calculated by interpolation.

Table 1
Number of participants at each school level according to years of experience.

Teaching level	Years of experience
Primary school	18 Males (7 LE, 4 AE and 7 HE) 4 Females (1 LE, 2 AE and 1 HE)
High school	24 Males (8 LE, 8 AE and 8 HE) 8 Females (5 LE and 3 HE)
College level (pre-university)	7 Males (3 LE, 1 AE and 3 HE) 3 Females (0 LE, 2 AE and 1 HE)
Total	24 LE; 17 AE; 23 HE

LE: less experienced (5 years or less); AE: average experience (6–15 years); HE: highly experienced (16 years or more).

2.2.3. Oxygen consumption

During their presence in the laboratory, participants were tested by progressive maximal modified Bruce protocol for treadmill exercise with 3-min increments (American College of Sports Medicine, 2009) to achieve a steady state. Before the stress test, the VO_2/Fc relationship was measured when the subjects were seated. Incremental testing was continued until VO_2max to ascertain the maximum aerobic capacity of each participant. Expired gases were assessed by Moxus metabolic analyzer (AEI Technologies, Pittsburgh, PA, USA) to measure VO_2. All devices were calibrated before each use. Criteria for determining the maximum were: 1) respiratory exchange ratio >1.10; 2) participant inability to continue the current level or to progress to another workload; 3) achievement of theoretical maximum HR, i.e. 220 − age; and 4) plateau identification (±150 ml) of VO_2 gain. At least 3 of these 4 mandatory criteria must be met with achievement of the required respiratory quotient.

2.2.4. HR at worksite

During treadmill testing, HR was recorded by Polar transmission belt coupled to a receiver connected to a data acquisition system (Polar S810 i, Polar Electro Oy, Kempele, Finland). The same monitor recorded HR during workdays. Research assistants went to all sites to install wrist HR monitors and hip accelerometers and to deliver task diaries for completion. At the end of the day, research assistants returned to all sites to collect the equipment and help physical educators complete their logbooks. HR and accelerometry counts were downloaded to our laboratory computer. These data were averaged over each 1-min period for further calculation. EE values during selected work phases were estimated by interpolation of VO_2/HR linear function specific to each individual.

2.2.5. Accelerometry and diary

Participants wore a belt accelerometer (Actigraph, MTI Health Services, Pensacola, FL, USA) during work to estimate amounts of movements during a given time period of the day. It served to verify movement periods occurring during work (every minute) and to corroborate diary entries. In the logbook, participants described tasks performed during the day in bouts of 10 min. After the analysis of all participant logs, we identified 4 categories of activities according to their EE: 1) office work: telephone, paperwork, meetings, marking of assignments, displacements in school or between schools, and course preparation, 2) supervision and monitoring: observation, monitoring at recess, student assessment, surveillance of facilities, student management and courses without demonstrations; 3) mixed participation: partly-active refereeing, demonstrations followed by educational supervision, assisting students in carrying out activities; 4) active participation: participation while teaching and active refereeing involving running and game's involvement at the same pace as the pupils.

2.2.6. Environmental control

In none of the data collection periods did temperature exceed 25.6 °C, a threshold value (Rowell, 1986). In fact, the 2 main data collection periods in spring were cooler than average (Environment Canada).

2.2.7. Statistical analysis

Data were expressed as means ± standard deviations. Data handling and statistical functions were undertaken with Excel 2010™. Pearson correlations were determined for specific relationships. Differences between averages of measured and calculated variables were compared by ANOVA using SPSS 15.0. The results were analyzed with the statistical tables of Laurencelle and