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Original Article

Comparison of daily physical activity parameters using objective methods between overweight and normal-weight children

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Purpose: The purpose of the present study was to determine if there were any differences in various aspects of physical activity such as energy expenditure, intensity, and type of activity between normal-weight and overweight boys.

Methods: Children aged 9–12 years were recruited from 2 elementary schools located in different urban districts in Republic of Korea. The present study included 45 Korean boys, of which 19 were normal-weight and 26 were overweight. Daily physical activity was estimated over the same 1-week study period under free-living conditions using the doubly labeled water (DLW) method and a tri-axial accelerometer. Resting metabolic rate (RMR) was measured using the Douglas bag method and open-circuit indirect calorimetry. We calculated the physical activity level (PAL) as the total energy expenditure (TEE)/RMR.

Results: PAL was not significantly different between the groups. In the accelerometer data, time spent in locomotive moderate-to-vigorous physical activity (MVPA) was significantly lower in overweight boys than in normal-weight subjects, whereas other variables including non-locomotive activity did not differ between groups. In addition, among all participants, time spent in total locomotive activity was significantly associated with PAL. Time spent in locomotive MVPA was significantly associated with PAL.

Conclusion: Overweight boys may be less physically active based on locomotive MVPA, which was positively related with PAL. Our findings suggest that the contribution of locomotive MVPA to the increase in PAL was relatively significant.

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Keywords: Accelerometer; DLW; Locomotive MVPA; Korean elementary boys; Obesity; PAL

1. Introduction

The prevalence of childhood obesity is steadily increasing in the US over the past few decades, from 6.5% in 1976–1980 to around 18.0% in 2009–2010 among children of ages 6–11 years.^{1–3} A similar trend has been seen in Asian countries,^{4–6} except in Japan.⁷ Specifically, the number of overweight or obese children in Korea has progressed rapidly among school

children aged 7 to 12 years, reaching 12.3% in 1997 and 20.9% in 2005, although the number has increased more slowly in non-school aged children of ages 2–6 years from 14.4% to 16.3%.⁸ One of the possible causes of the rapid progression of obesity among Korean school children may be the reduction in physical activity levels (PALs). Korea has experienced rapid urbanization, consequently children now have limited places to play close to their homes. Meanwhile, time spent in sedentary behaviors including the use of computers has increased in urban Korean school-aged children and this has been associated with the risk of obesity.^{9,10} Childhood obesity is positively associated with increased risk for many health issues in children such as

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type 2 diabetes, cardiovascular disease, and psychosocial problems.^{11–13}

A significant target for preventing childhood obesity is daily physical activity (PA).¹⁴ Daily PA is composed of various aspects such as energy expenditure, intensity, and patterns. The doubly labeled water (DLW) method is considered the most accurate method for measuring total energy expenditure (TEE) in free-living conditions.^{15,16} In DLW studies among Western children, the majority of studies showed no differences in PAL, which is the ratio of TEE to the resting metabolic rate (RMR) between overweight and normal-weight subjects.^{17,18} However, PAL data using the DLW method for Asian overweight children has not yet been reported.

On the other hand, a different definition of PA, such as time spent at moderate-to-vigorous physical activity (MVPA) assessed by accelerometry, showed that overweight children had much lower MVPA compared with normal-weight participants.^{19,20} The United States Centers for Disease Control and Prevention recommend that children should engage in 60 min of daily MVPA for 5 out of 7 days to achieve health benefits.²¹ However, evidence indicates that more than 50% of children do not meet the recommendation of 60 min of daily MVPA.^{22,23} Thus, many intervention studies using accelerometers for promoting PA among children have been performed.^{24–27} In a randomized, controlled trial, Goldfield et al.²⁸ clearly demonstrated that MVPA could be increased by intervention using accelerometry in overweight and obese children.

Recently, our group developed an algorithm using a triaxial accelerometer that can discriminate locomotion from non-locomotion PA.^{29,30} With this algorithm, such discrimination between locomotive and non-locomotive PA enables more accurate evaluation of PA intensity.^{31,32} Locomotive activities include activities such as walking with a back pack, running, and stair climbing; non-locomotive activities are activities such as performing a ball toss. Wii Tennis (swing performance) and washing the floor are examples of activities of daily living, especially in relation to MVPA.^{31,33,34} At least in pre-school children, non-locomotive time was much longer than locomotive time during medium-intensity PA in free-living Japanese preschool children.³⁵ Moreover, non-locomotive activities significantly contribute to TEE under free-living conditions in the case of adults.³⁶ Thus, we believe it would be beneficial to understand the activity patterning of locomotion and non-locomotion as well as intensity among children. However, to our knowledge, examination of whether there are differences in the time spent in activity for locomotion or non-locomotion between overweight and normal-weight elementary school children has not been carried out.

In the present study, we combined the DLW method and tri-axial accelerometry to determine whether there were any differences in various aspects of daily PA with regard to energy expenditure, intensity, and type of activity between overweight and normal-weight boys. Furthermore, we clarified which types of PA, such as locomotion and non-locomotion, were related with PAL in elementary school children. This study will enable us to understand in more detail the possible role of PA in childhood obesity.

2. Methods

2.1. Experimental procedures

This study was performed in Korea in April of 2010, which is the spring season in Pohang city (Pohang study), and in November of 2013, which is the fall season in Gangneung city (Gangneung study). Pohang city is well-known for its developed industry and higher education. Gangneung is a major tourist city. The 2 cities are located near the sea. Of importance to this study, the 2 cities have recently experienced rapid urbanization but have a relatively inconvenient transportation system with no subway and inconvenient bus services compared with larger major cities such as Seoul. Many children in these areas are forced to be driven by car to commute to school or to travel some distance to find a place to play with friends outside. We selected 2 elementary schools located in the most urbanized districts in each city. The first semester of elementary school was from March to July and the second semester was from September to February. In the Pohang study, we performed an experimental procedure at the elementary school before the start of the first class. In the Gangneung study, children attended the study center of Gangneung-Wonju National University during school holidays. On the day before the commencement of the assessment of PA, urine samples (baseline) were collected and body weight and height were measured. A single dose of DLW was then given orally to each subject. After administration of this dose, the participants were requested to also collect urine samples 5 times on the following 8 days at the same time of the day. The RMR was measured in the early morning 12 h or longer after the last meal during the study period. Subjects were instructed to wear an accelerometer during the study period and asked to keep a 3-day dietary record.

2.2. Subjects

Children aged 9–12 years were recruited from 2 elementary schools located in urban districts of Pohang and Gangneung, Korea. We announced this project to all teachers from the school to recruit participants according to the following criteria: (a) in good health, (b) not involved in hard PA such as young athletes, (c) living in their home prefecture 2 weeks before and during the study. Parents were also informed that the study concerned the measurement of daily PA and food intake of children. A total of 49 boys were recruited in the present study. Four boys failed to collect urine samples for measurement and thus, the data of 45 boys (Pohang study, 25 boys; Gangneung study, 20 boys) were used in the present study analysis. This study was conducted according to the guidelines specified in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethical Committee of the National Institute of Health and Nutrition in Japan (Pohang study) and by the Ethical Committee of Gangneung-Wonju National University (Gangneung study). A written informed consent was obtained from all subjects and their parents. This study was also approved by the School Board Officials of the 2 elementary schools prior to starting the studies.

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