SECULAR TRENDS AND CONTEMPORARY DIFFERENCES IN PHYSIQUE AND HEALTH-RELATED FITNESS LEVELS OF 11-12 YEAR-OLD SOUTH KOREAN AND NEW ZEALAND CHILDREN

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Abstract. Physique and physical fitness levels of 343 South Korean and 260 New Zealand 11-12-year-old schoolchildren were measured between 2000 and 2001 and added to previous data to investigate secular trends and contemporary patterns in these health-related variables. Secular trend data suggest that South Korean children are growing taller at a faster rate but are also increasing in body mass faster than New Zealand children. Contemporary South Korean children had significantly higher sit and reach and broad jump scores compared to New Zealand children, however aerobic fitness was similar between the cohorts except for 11-year-old New Zealand girls who took significantly longer to complete the 550-m run. Contemporary South Korean and New Zealand children's physiques are similar at present but if current trends continue South Korean children will become more obese than their New Zealand counterparts. An increase in South Korean children's fat mass will also have a detrimental effect on their currently superior fitness levels and overall health.

INTRODUCTION

Recently there has been a dramatic change in the physique of children from industrialized countries resulting in an increased prevalence of children classified as overweight or obese (Bundred *et al*, 2001). In addition, a marked decline in physical fitness is also evident (Dollman *et al*, 1999; Dawson *et al*, 2001), along with a corresponding increase in the prevalence of sedentary-related health problems such as Type 2 diabetes (Rosenbloom *et al*, 1999), low bone mass (Goulding *et al*, 2000), high lipid levels (Freedman *et al*, 1992) and hypertension (Hill and Trowbridge, 1998). These sedentary-related diseases are set to increase in countries where children do not participate in sufficient physical activity levels to meet health guidelines (Calvert *et al*, 2001), or where current levels of physical activity are trending downward (Tomkinson *et al*, 2003). A lack of opportunity or unwillingness to be physically active, along with an increasingly mechanistic and affluent society and an ever more popular Western-style diet probably plays a large role in these changes (Dollman *et al*, 1999).

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South Korea has experienced significant economic growth and lifestyle change since the end of the Korean War (1950-1953). Western influences, such as fast-food restaurants, computer and video games have been introduced and are popular, particularly with younger people. There is evidence that South Korean children's body mass has been steadily increasing since 1954 (Kim *et al*, 2000), probably due to better nutrition after the Korean war, but it is not known whether the body mass of contemporary South Korean children now matches or exceeds the body mass of children from developed countries, or whether the rate of body mass increase is the same between developed and developing countries. There is also evidence that aerobic fitness in young South Koreans (10-17 years) is declining (Ministry of Culture and Tourism, 1998; Ministry of Education, 1999), but it is unclear whether the health-related fitness levels of South Korean children differ significantly from children from other developed countries, such as New Zealand. The purpose of this study was to determine whether contemporary South Korean children have different physiques and/or health-related fitness levels compared to New Zealand children. In addition, we also wanted to determine secular trend differences in height, weight, and body mass index (BMI) between South Korean and New Zealand children to establish possible contributing factors.

MATERIALS AND METHODS

Subjects

Subjects were 11 and 12-year-old students living in Daegu, Korea and Christchurch, New Zealand. Table 1 represents the gender and age-specific characteristics. The ethnic make-up of the New Zealand sample was similar to that of New Zealand as a whole, with approximately 85% of children classified as European, 10% Maori or Pacific Islander and 5% Asian. All Korean children were of Asian decent. The collection of data occurred between 2000 and 2001. Some of the data collected in this study was also compared to data from previous New Zealand (Dragicevick *et al*, 1987; Russell *et al*, 1989; George *et al*, 1993) and South Korean surveys (Daegu City Office of Education, 2002) to determine if any secular trends could be elucidated. This study had the approval of The Canterbury Ethics Committee, New Zealand (reference 00/04/042), and written informed consent was obtained prior to the study from each participant and their parent or legal guardian.

Testing

The testing parameters and procedures completed on both groups of children were identical to tests completed on children in earlier surveys (Russell *et al*, 1989). Children were tested by the same researchers at their own school, during school hours in light clothing with shoes removed for height (stretch stature method with a Seca stadiometer, Hamburg, Germany) and weight with calibrated portable scales (Seca, Hamburg, Germany). Children's sit and reach, broad jump and 550-m run performances were also measured and a full description of these tests is published elsewhere (Russell *et al*, 1989).

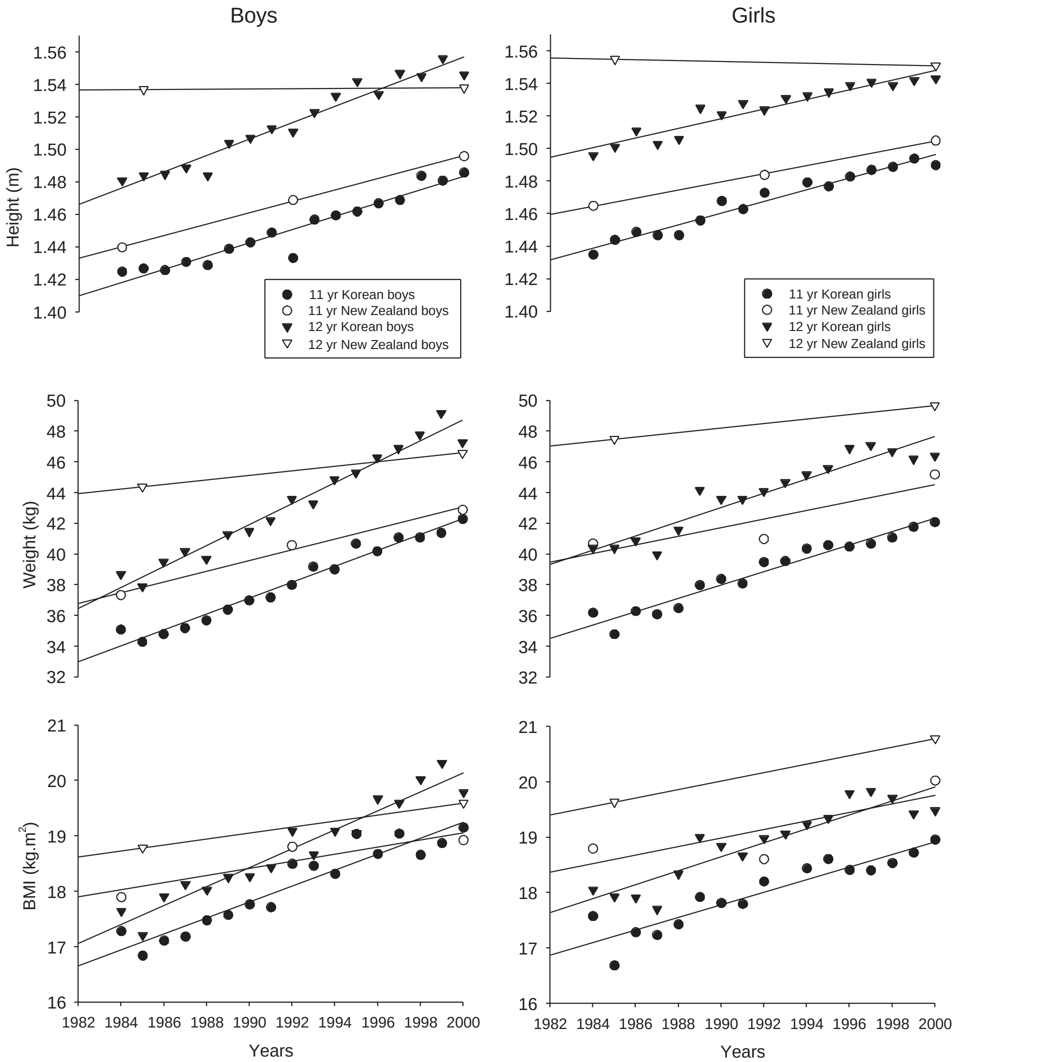
Statistics

An unpaired *t*-test assuming unequal variance was used to analyze the differences in the physique and fitness parameters between the South Korean and New Zealand children. A p-value of 5% was chosen for declaration of statistical significance. A linear regression model was fitted to the secular data to establish trends.

RESULTS

Secular trend data

In the New Zealand 12-year old boys and girls, the average height did not change dramatically between 1984 and 2000 (0.06 and -0.26 cm/decade, respectively), however over the same period the average heights of South Korea boys and girls increased substantially (5.02 and 2.96 cm/decade for boys and girls, respectively) (Fig 1). Although 11-year old New Zealand boys (3.5 cm/decade) and girls (2.5 cm/decade) have increased in height since 1984, they did not match the height increase witnessed in South Korean 11-year olds (4.08 and 2.96 cm/decade for boys and girls, respectively). The average body weight of South Korean boys increased between 1984 and 2001 by 5.18 kg/decade (11-year olds) and 6.8 kg/decade (12-year olds), compared to 3.46 kg/decade and 1.46 kg/decade in New Zealand boys. Similarly South Korean girls increased their average body weight over the same period by 4.34 kg/decade (11-year olds) and 4.62 kg/decade (12-year olds), which was considerably higher than the New Zealand girls over the same period (2.81 and 1.46 kg/decade for 11 and 12-year olds, respectively). Since the average weights of South Korean children increased at a greater rate than their body height, their BMI also increased substantially. The average South Korean boys' BMI increased by 1.44 kg/m^2/decade (11-year olds) and 1.71 kg/m^2/decade (12-year olds) from 1984 to 2001, while over the same period the average South Korean girls BMI increased by 1.13 kg/m^2/decade and 1.26 kg/m^2/decade for 11 and 12-year olds, respectively. The BMI increases for New Zealand children were substantially less than their South Korean counterparts (0.64 and 0.54 kg/m2/decade for 11 and 12-year old boys and 0.76 and 0.75 kg/m^2/decade for 11 and 12-year old girls).



Data are means with linear regression trend lines; New Zealand data is from Dragicevick *et al* (1987), Russell *et al* (1989), George *et al* (1993). South Korean data are from (Daegu City Office of Education (2002).

Fig 1–Secular trends in height weight and BMI in South Korean and New Zealand children.

Cotemporary data

South Korean and New Zealand 11-12-year-old boys and girls were similar in height (Table 2). There were no statistically significant differences between the average body masses of the South Korean and New Zealand boys, however, New Zealand girls were significantly heavier than their South Korean counterparts.

In general, Korean boys and girls scored higher in the sit and reach and broad jump tests than their New Zealand counterparts (Table 3). The aerobic fitness of the two groups as measured by the 550-m run was similar, except for the 11-year-old New Zealand girls who were significantly slower in completing the run than their South Korean cohorts.

DISCUSSION

It is well established that the body mass of New Zealand children has increased over the last decade or so (Dawson *et al,* 2001). This trend of increased body mass is also found in South

Table1
Subject numbers in each age and gender group.

Country	Gender	Age 11-years	Age 12-years
South Korea	Male	94	76
	Female	93	80
New Zealand	Male	60	75
	Female	60	65

Korea. The results of this study show that the average body mass of South Korean 11 and 12 year-olds living in Daegu in 2000-2001 was 42.2 and 46.8 kg, respectively, which is an increase from 35.6 and 39.5 kg recorded in 1984 (Daegu City Office of Education, 2002). This increase in body weight over time matches that found in younger and older South Korean and New Zealand children (Kim *et al,* 2000; Dawson *et al,* 2001) and has probably contributed to the recently reported increases in the proportion of

Table 2
Height, body weight, and BMI comparisons between South Korean and New Zealand 11-12-year-olds.

	Age	Gender	Korea	New Zealand	*t*-value
Height (cm)	11	Male	148.6 ± 6.8 (n=94)	149.6 ± 6.9 (n=50)	0.808
		Female	149.0 ± 6.2 (n=93)	150.5 ± 8.0 (n=42)	1.068
	12	Male	154.6 ± 8.4 (n=76)	153.8 ± 8.5 (n=75)	0.613
		Female	154.3 ± 5.8 (n=80)	155.1 ± 7.4 (n=54)	0.632
Weight (kg)	11	Male	42.3 ± 10.7 (n=93)	42.9 ± 11.1 (n=48)	0.318
		Female	42.1 ± 7.5 (n=93)	45.2 ± 9.6 (n=41)	1.800[a]
	12	Male	47.3 ± 10.3 (n=76)	46.6 ± 10.0 (n=73)	0.394
		Female	46.4 ± 10.8 (n=80)	49.7 ± 11.6 (n=80)	1.598[a]
BMI (kgm^2)	11	Male	19.9 ± 3.7 (n=93)	18.9 ± 3.7 (n=48)	1.388
		Female	18.2 ± 2.6 (n=93)	20.0 ± 3.8 (n=40)	2.789[a]
	12	Male	21.1 ± 4.1 (n=76)	19.6 ± 3.2 (n=69)	2.386[a]
		Female	20.1 ± 4.0 (n=80)	20.8 ± 4.2 (n=48)	0.929

Data are mean ± SD; Subject numbers for each group are given in brackets.
[a]Significant difference between South Korean and New Zealand groups at the 0.05 level. Body Mass Index (BMI).

Table 3
Fitness comparisons between South Korean and New Zealand 11-12-year-olds.

	Age	Gender	Korea	New Zealand	t-value
Sit and reach (cm)	11	Male	29.2 ± 5.9 (n=93)	21.9 ± 13.7 (n=48)	4.496[a]
		Female	34.7 ± 8.1 (n=92)	24.6 ± 9.0 (n=39)	3.298[a]
	12	Male	30.7 ± 8.7 (n=74)	19.7 ± 9.6 (n=51)	7.956[a]
		Female	39.7 ± 5.2 (n=80)	26.4 ± 9.3 (n=39)	12.397[a]
Broad Long jump (cm)	11	Male	182.2 ± 20.4 (n=94)	172.2 ± 23.2 (n=50)	2.507[a]
		Female	156.5 ± 19.4 (n=93)	156.1 ± 28.9 (n=42)	0.064
	12	Male	205.2 ± 39.5 (n=76)	177.5 ± 30.3 (n=73)	4.807[a]
		Female	171.5 ± 16.5 (n=80)	160.1 ± 27.3 (n=50)	2.674[a]
550-m run (sec)	11	Male	159.1 ± 23.7 (n=93)	150.6 ± 27.8 (n=51)	1.933
		Female	161.7 ± 20.3 (n=93)	178.5 ± 37.9 (n=37)	2.560[a]
	12	Male	153.9 ± 19.8 (n=72)	159.2 ± 38.1 (n=76)	1.043
		Female	168.3 ± 21.5 (n=75)	172.6 ± 39.5 (n=51)	0.779

Data are mean ± SD; Subject numbers for each group are given in brackets.
[a]Significant difference between South Korean and New Zealand groups at the 0.05 level.

children classified as overweight or obese in South Korea and New Zealand. Recent research found that the proportion of New Zealand boys classified as overweight or obese almost doubled between 1991 and 2000 (from 4.2% to 7.8%) while over the same period the proportion of overweight or obese New Zealand girls increased from 2.0% to 11.3% (Dawson *et al,* 2001). In South Korea the proportion of obese boys increased from 9% in 1984 to 19% in 1994, while over the same period the proportion of obese girls climbed from 9% to 16% (Lee, 1996).

The body mass index, which is calculated by the dividing body weight (kg) by the square of the body height (m) is merely the ratio of body mass to body height. However, in the absence of more sophisticated testing procedures it is commonly used as an indication of body composition. Previous studies have found high correlations between BMI and more sophisticated tests to measure fat, including skinfold totals (Dollman *et al,* 1999), magnetic resonance imaging (Chan *et al,* 1998), and bioelectrical impedance (Tyrrell *et al,* 2001). This study found that contemporary New Zealand girls had higher BMI scores than their South Korean counterparts, whereas New Zealand boys had lower BMI scores compared to South Korean boys of the same age. The higher BMI scores in both cases were associated with elevated body mass rather than any difference in height between the cohorts (Table 2).

Longitudinal data is useful in highlighting trends in anthropometric information, such as height, weight and BMI. It can be seen that South Korean children have been growing taller more rapidly than New Zealand children since 1984, but they are also putting on weight at a faster rate than the New Zealand children. For New Zealand children, particularly the 12-year-olds, the increased BMI over this period is due to an increase body mass rather than any increase in overall stature, since the heights of New Zealand 12-year-olds have not changed markedly over the last decade (Dawson *et al,* 2001). Similarly, although New Zealand 11-year-old and South Korean 11-12-year-old children have increased in height since 1984 by about 3-4%, their body mass has increased much more rapidly (20-21%) (Daegu City Office of Education, 2002). This disproportionate increase in mass in relation to height was previously identified in Australian schoolchildren (Dollman *et al,* 1999) and suggests at least some increase in body fat levels. Measures that indicate body fat levels have implied that the recent increase in children's weight in developed countries is most likely to be due to increased adipose tissue (Olds and Harten, 2001). However in developing countries, like South Korea, some of the increase in children's BMI is probably associated with increased height due to improved dietary practices that have followed the rapid economic growth and increased personal wealth of its citizens (Kim *et al,* 2000). Nevertheless, if South Korean children's body weight continues to increase disproportionately to their body height, future health problems, including increased obesity, type 2 diabetes, bone problems and cardiovascular disease, are likely.

Flexibility is related to many factors, including the state of fitness, amount of physical activity, posture and age (Corbin, 1984). It has also been suggested flexibility has a strong genetic influence (Ohyama, 1970), which may explain the surprisingly different sit and reach scores between contemporary New Zealand and South Korean children. While the sit and reach test was designed to indicate hip and trunk flexibility it must also be realized that the sit and reach test, as we have administered it in this study, has inherent limitations that do not allow for proportional differences between arm and leg lengths (Hoeger and Hopkins, 1992). Children that have long legs or short arms are disadvantaged resulting in lower scores. It is possible that New Zealand children are disadvantaged in this way, however, further research measuring arm and leg length differences between New Zealand and Korean children is required to support this hypothesis. Other factors, such as the type of play and sporting differences between the two countries as well as differences in diet and genetic make-up, are probably involved.

South Korean children, except for 11-year-old girls, had significantly better broad jump scores than their New Zealand counterparts. The improved jumping ability of the South Korean children may be due to a better power-to-weight ratio these children produce because of their lower body mass compared to the New Zealand children. A lighter body with the same muscle mass would produce more power and result in a greater distance jumped. Alternatively, since South Korean children use the broad jump test in their annual physical fitness tests, the improved scores may also be due to a learning effect. Such a learning effect has been suggested for the improved fitness scores in United States children between 1957 and 1965 (Kuntzleman and Reiff, 1992).

Overall, little difference between the two groups was found in the 550-m run, although 11-year-old South Korean girls were significantly faster than their New Zealand counterparts. Since 11-year-old South Korean girls had significantly less body mass, the improved 550-m run score would be expected as the heavier New Zealand girls would have to carry more body weight over the same distance. Previous research has found $\dot{V}O_{2max}$ decreases as BMI increases in similar-aged children (Tomkinson *et al,* 2003) which would lead in this case, to significantly slower run times. This was probably also the case for the 12-year-old girls, but because of the large variation in the 550-m run performances in this group the differences were not significant. However, this study also found no significant difference in the 550-m run scores between the 12-year-old boys, yet the South Korean cohort had significantly higher BMI's. This inconsistency in the BMI's influence on aerobic performance suggests the increases in the BMI cannot explain all the differences in aerobic fitness between the two cohorts.

Researchers have found that ethnicity is not a significant factor in endurance performance (Diprampero and Cerretelli, 1969) which suggests the differences found between New Zealand and South Korean children in the current study were probably due to environmental factors. A decrease in the level of children's physical activity is likely to be a major factor, not only in the overall lower fitness scores of the New Zealand cohort but also of the secular BMI changes in this group. Recent research using a proxy-reporting methodology has found a small but significant decline in the proportion of young New Zealanders classified as physically active from 69% in 1997-1998 to 66% in 2000-2001 (Sport and Recreation New Zealand, 2003). A more objective methodology using heart rate monitors to attain activity levels suggests the number of active young people in New Zealand is much lower (Calvert *et al,* 2001). Factors associated with lower activity levels in New Zealand children include decreased scheduled physical education at school (Ross and Cowley, 1995), urban drift, the rise of the two-income family, smaller house sections, easy access to inactive leisure pursuits, such as television, computer and video games, as well as the increased technology and mechanization of New Zealand society (Ross, 2000). These environmental factors are also becoming well established in South Korea with its booming economy and rise in wealth, which has enhanced purchasing power (Kim *et al,* 2000).

Chronic lifestyle diseases, such as cardiovascular disease, diabetes, stroke and obesity, have taken over from infectious diseases as the major killers of New Zealander adults (Hay, 1996). In a recently released report, insufficient physical activity and high BMI accounted for 21% of all New Zealand deaths in 1997 (Ministry of Culture and Tourism, 1998). This trend is also emerging in South Korea with more people dying from diseases of the circulatory or respiratory system than from traditional infectious or parasitic diseases (Kim *et al,* 2000). Most of these health problems in adults are closely associated with poor nutritional habits and/or a lack of physical activity, and these diseases or their risk factors are now becoming apparent in children from developed countries (Freedman, 2002) and South Korea (Lee, 1996).

In conclusion, contemporary South Korean children's physiques are similar to those of New Zealand children and are probably influenced by the same environmental factors. However, fitness levels between the two cohorts show some differences, which may be explained by social, cultural and genetic factors. While the gradual increase in South Korean children's stature over the last 18 years is probably a result of improved nutrition, the trend for an even steeper increase in these children's body weight and BMI is worrying. Health officials and government agencies from both South Korea and New Zealand need to stress the importance of physical activity and healthy eating to their children.

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