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THE NEXUS OF HOURS OF COMPUTER USE, PHYSICAL ACTIVITY AND PHYSICAL FITNESS OF PUPILS IN SINGAPORE

An Educational Research Funded Project

[EP3/99 MC]

A report on the relationships between hours of computer use, physical activity and physical fitness of pupils in Singapore

By

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SINGAPORE

Foreword

Dedication

For the young & the restless and those who believe in them

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Contents

PREAMBLE

Young people have a natural inclination for play and physical activity and there are data, which support that lifestyle habits such as physical activity and love for physical activity are inculcated during the formative years of childhood and adolescents.

There are concerns that sedentary lifestyle habits such as increased hours of computer use contribute to less physical activity time and reduced physical fitness among young people. Arguments that increased hours of computer use may displace physical activity and may be detrimental to physical fitness have come to the fore. Yet data supporting these arguments are equivocal.

Some data in adults and adolescents show a positive relationship between hours of television viewing and obesity rates but this situation may be exacerbated by the associated consumption of energy dense snacks during television viewing. However, the association between hours of computer use and obesity is less clear and is in need of further study.

Advocates of physical activity and physical fitness suggest that increased hours of computer use and television viewing are detrimental to physical activity and physical fitness but data supporting the assertion are not secure and more study in the area is required.

Many believe that physical activity and physical fitness are inherently connected- that physically fit young people are also physically active. However, the association between physical activity and physical fitness is not a simple one. Physical activity describes lifestyle behaviour whereas physical fitness is an attribute or a descriptor of a person's capability to perform functional work. There are also views that specific levels of physical fitness for daily living among young people need to be addressed.

Data from the present study was presented at a National Conference hosted by the Health Promotion Board, Ministry of Health in Singapore in September 2002. The results of the research were published in the European Journal of Physical Education, Volume in 2002.

SUMMARY

The purpose of the study was to examine the relationships between hours of computer use, physical activity and physical fitness of 120 pupils (mean age = 10.6 years) from a primary school and 120 pupils (mean age = 14.8 years) from a secondary school. Information about self-reported computer use and physical activity was garnered from questionnaire responses.

Heart rate (HR) data (i.e. total time spent at HR<120, 120-139, 140-159 and >160 beats per min^{-1} [bpm]) using a telemetric system (Polar Vantage, NV) were collected over an average 10-hour period (0800-1800 hours) on two weekdays and a weekend day from 30 boys and 30 girls (aged 10-15 years).

Physical fitness data (1.6/2.4 km run, sit and reach, 4x10m shuttle-run, 1-min bent knee sit up, incline flexed arm hang/pull-up and standing broad jump) of all pupils was also collected.

Results showed that 98-100% of pupils had previous experience using computers and 98-100% of pupils had access to computers. Hours of computer use per week increased with age (from 10-11 years to 14-15 years) (6.0 ± 5.0 vs. 8.6 ± 7.7 hours, $p<0.05$).

No meaningful relationships were detected between hours of computer use per week, physical activity, and physical fitness except a small but significant correlation between hours of computer use and physical activity in primary school pupils.

Time spent at HR intensities 120-139 (beats per minute) bpm, 140-159 bpm and >160 bpm revealed that most pupils were largely physically inactive (i.e. HR<120 bpm) during the weekday (90.2%) and especially on the weekend day (97.8%).

Accumulated physical activity based on HR intensities described as light (HR 120-139 bpm), moderate (HR 140-159 bpm) and vigorous (HR >160 bpm) increased with age (from 10-11 yr to 14-15 years) for the weekday and the weekend day.

Accumulated daily physical activity of a moderate intensity (HR 140-159 bpm) in primary and secondary school pupils did not meet the recommended quality and quantity of physical activity for the maintenance of good physical health that are published in consensus statements of two international panels of experts.

INTRODUCTION

The use of information and communications technology (ICT) in schools in Singapore is not a recent phenomenon. Since 1981, the Ministry of Education (MOE) of Singapore has recognised the potential of ICT in education and has been involved in some pilot projects in schools, in incorporating the use of ICT for learning in curriculum subjects (MOE, 1995).

The use of ICT in schools in Singapore continues to increase at an unprecedented pace since the launch of the Singapore Information Technology (IT) Master Plan for Education in April 1997 (Kuo, Choi, Mahizhnan, Lee and Soh, 2002). The IT Master Plan for Education is part of the country's overall IT Master Plan, which is a two billion-Singapore-dollar initiative to wire up the entire island to make it an intelligent learning nation. Outside of school, pupils have access to computers and the Internet, either at home, at community clubs or at 'cyber-cafes'.

Health educators are concerned that the increased prevalence of ICT use among young people may result in increased levels of physical inactivity, increased juvenile obesity and reduced levels of physical fitness, factors that may be harmful to health in the medium to long term (Chia, Teo-Koh, Tan and Quek, 2000; Kerner, Kalinski, Kurrant, Small, Spatz and Gropack, 2001). However, not all the evidence is consistent.

For example Robinson, Hammer, Killen, Kraemer, Wilson, Hayward and Taylor (1993) reported that in 279 girls aged between 11 and 13 years of mixed racial composition (43% white, 22% Asian, 21% Latino, 2% Pacific Islander, 2% American Indian and 2% other), hours of television viewing after school was not associated with adiposity (body mass index and triceps skinfold thickness) or self-reported physical activity over measurement periods taken at 7, 14 and 24 months after baseline measurements (N=671) were taken.

On the other hand, others (e.g. Dietz and Gortmaker, 1985) argue that obese children spend more time watching television than lean children. A questionnaire was completed by two cohorts of children and adolescents. One cohort consisted of 6965 children aged 6-11 years and the other cohort comprised 6671 children aged 12-17 years. Results showed that for 12-17-year-old adolescents, the prevalence of obesity increased by 2% for each additional hour of television viewed.

Increased use of multimedia technology (television, video games, and computer) has been suggested as one of the significant causes of increased patterns of physical inactivity among young people (e.g. Armstrong and Welsman, 1997; DuRant, Thompson, Johnson and Baranowski, 1996; Pate, Trost, Felton, Ward, Dowda and Saunders, 1997). Others (e.g. Robinson, 1999; Walker and Gerhardt, 1990) have argued that behaviours that are associated with television and video watching, such as hours of physical inactivity and incessant snacking on high fat, high sugar and energy dense foods are the main culprits of increased juvenile obesity.

However, whether such physical inactivity that may be compromising to health is associated with hours of computer use remain to be elucidated. Additionally, data

garnered from many developed countries in the UK (e.g. Welsman and Armstrong, 2000) and in Singapore (e.g. Gilbey and Gilbey, 1995; Lim, 1995) have shown that regular habitual physical activity declines as pupils move from primary to secondary school. This observation mirrors trends of reduced physical activity observed in adults as they get older between, early adulthood and mid-adulthood (National Health Survey 1998; Sallis and Owen, 1999).

It has been suggested that more young people spend increased amounts of time on a computer engaged in forms of cyber-activity, either for information or for leisure (Chia *et al*., 2000). Findings from a survey of 1,330 pupils aged 12-13 years old in Singapore revealed that boys and girls spent an average of 5.4 hours per week on a computer engaged in Internet activities such as sending email, using search engines, downloading information and joining on-line chat groups (Kuo *et al*, 2002).

Another study conducted in the USA on the use of the Internet in ninth grade African-American girls aged between 13 and 14 years showed that hours spent on the Internet for leisure-time activity was between 2.04±0.95 hr/wk (Internet low user, N=54) and 9.17±8.6 hr/wk (Internet high user, N=56). This form of leisure-time activity appears to contribute to the same hypokinetic behaviour as television watching (Anderson, Crespo, Bartlett, Cheskin and Pratt, 1998).

However, research on physical activity in young people (Armstrong and Welsman, 1997) and promoters of physical activity and young people's health (A computer and Quek, 2002) and advocators of heart health (Harris and Elbourn, 1990) have used ICT to further their cause. Chia *et al*. (2000) suggested that computer technology could be a boon or bane to physical education (PE) depending on whether the technology is harnessed to enhance or promote PE.

Physical activity among primary and secondary school pupils in Singapore has been described as inadequate for the development and maintenance of physical fitness (Gilbey and Gilbey, 1995; Lim, 1995). Gilbey and Gilbey (1995) used HR monitoring on 50 boys and 64 girls aged nine and 10 years over three 14-hour periods and Lim reported on the HR data, derived from 12 hours of monitoring, of 120 boys and girls aged 13 to 14 years over three weekdays and one weekend day, to estimate habitual physical activity among young people in schools.

Both sets of researchers reported that very few primary school pupils (18% of boys and 6.3% of girls) and secondary school pupils (less than 10% of boys and girls) achieved at least 10-20 minutes of sustained aerobic-type activity that resulted in a HR>140 bpm. However, in these studies, American College of Sports Medicine (ACSM) guidelines or standards (sustained 10 to 20 minute bouts of moderate to vigorous physical activity) (ACSM, 1995) that were meant for adults for the development and maintenance of cardiovascular health and fitness were applied to young people for data interpretation.

Pangrazi (2000) argued that most young people do not have the motivation or the inclination to pursue physical activity that is of a sustained nature, given their shorter attention span compared to adults. Sustained steady-state activity is also uncharacteristic of the natural habitual activity of young people either as part of daily activity or during unstructured play (Chia and Quek, 2001). Moreover, health protagonists are of the view that high levels of sustained physical activity are not necessary for most health benefits to accrue, and importantly, such requirements are beyond the achievement of most young people (Biddle, Cavill and Sallis, 1998; Pangrazi, 2000). Therefore there is a need to use the criterion for measuring the physical activity habits of young people that is appropriate for their patterns of exercise so as to avoid erroneous conclusions.

Current recommendations for health-promoting physical activity for young people are that young people should be physically active every day and should accumulate the equivalent of 30 to 60 minutes of moderate intensity physical activity per day (Biddle, Cavill and Sallis, 1998; Chia and Quek, 2001; Pangrazi, 2000;). Physical activity and/or exercise of a moderate intensity have been described as that which elicits a HR response of between 140-159 bpm in young people (Armstrong and Welsman, 1997).

These recommendations take into account the nature of young people's physically active play behaviour, which is characterized by multiple bouts of short duration physical activity. Berman, Bailey, Barstow and Cooper (1998) reported that spontaneous play behaviour of prepubertal girls and boys is typified by many activity bouts (26-28 per hour), is variable in intensity (by direct observation) and each bout is of a short duration (20-21 seconds).

There are apparently no data on the physical activity of young people in Singapore, which make reference to the recommendations for health-promoting physical activity. Neither are there data that have elucidated the relationship between daily cumulative levels of physical activity and physical fitness of boys and girls.

AIMS

The purpose of the present study was to investigate relationships between hours of computer use, physical activity and physical fitness of a group of primary and secondary school pupils.

Another purpose of the study was to examine the daily accumulated time spent at HR intensities described as sedentary (HR<120 bpm), light (HR 120-139 bpm), moderate (HR 140-159 bpm) and vigorous (HR>160 bpm).

METHODS

Participants

Two hundred and forty pupils (120 girls and 120 boys) from two primary and two secondary schools in Singapore were involved in the study. Sixty boys and 60 girls, aged between nine and 10 years of age (academic level – Primary 5) were recruited from two primary schools. Another 60 boys and 60 girls, aged between 14 and 15 years old (academic level – Secondary 3) were recruited from two secondary schools. The primary and secondary schools represented government-funded schools in Singapore.

All pupils were free from any medical ailments and were classified as within the healthy weight-height range (i.e. between 90 and 110% based upon norms of weight for height) in accordance with the criteria published by the School Health Services of the Ministry of Health in Singapore (School Health Service, 1993). All pupils gave informed written consent to participate in the study, and the conduct of the study had the required institutional ethical clearance.

Measurement procedures

The principal investigator, one graduate student and four trained PE teachers conducted all measurements in the schools between 0900 and 1700 hours. Data collected included questionnaire responses on computer use and accessibility and physical activity, HR monitoring over a mean period of 10 hours on two weekdays and one weekend day and a physical fitness test battery consisting of six test items.

Questionnaire and physical fitness data were collected from all 240 pupils and HR monitoring data was collected from a random sub-sample of 30 boys and 30 girls, equally distributed across the two age groups. The order of data collection was questionnaire administration, HR monitoring and then physical fitness. The entire data collection took five weeks. Questionnaire data and HR data were collected within the first two weeks on three separate sessions while physical fitness data was collected over the next three weeks on two separate sessions.

Questionnaire

The questionnaire consisted of three sections: personal particulars, computer use and physical activity. Pupils were assured of the confidentiality of responses, were instructed that there were no right or wrong answers and were encouraged to ask questions if they were unclear about the questionnaire items. Pupils took about 15 minutes to complete the questionnaire in a quiet classroom.

The section of the questionnaire on computer use was adapted with permission, using aspects of the questionnaire for students in the World Internet Project (WIP, 1999, cited in Kuo *et al*, 2002). Hours of computer use for school-related work (e.g. word processing, completing worksheets, and fact and information searches using the Internet) and leisure-related activities (e.g. emailing, watching videos, and playing computer games) were determined based on the sum of four questionnaire items. These four items specified the four possible locations where pupils were most likely to

have access to computers. These included the home, school, libraries and others (specified by the pupils).

Information about pupils' physical activity data was obtained using 'The Physical Activity and Exercise Questionnaire' (Schmidt, Walkuski and Stensel, 1998). Construct validity of the questionnaire has been established previously with total cholesterol ($r=0.35$, $p<0.05$), high density lipoprotein ($r=-0.38$, $p<0.05$) and triglycerides ($r=-0.27$, $p<0.05$) on a group of 745 pupils aged 6-18 years, and the test-re-test reliability coefficient was reported as 0.67 (Schmidt, et al. 1998).

In the questionnaire, pupils were asked to describe their physical activity. Four choices were available; very light physical activity (e.g. walk or stand for 3-4 hours daily with no regular organised leisure time physical activity), light physical activity (e.g. occasionally involved in recreational activities such as tennis, jogging, swimming, cycling, etc), moderate physical activity (e.g. regular involvement in stair-climbing and recreation or fitness activities such as jogging, swimming, soccer or cycling at least three times a week for 20-60 minutes per session) and vigorous physical activity (e.g. regular involvement in extensive physical activity for at least 60 minutes per session for at least 4 times a week).

Physical fitness tests

Pupils' physical fitness was assessed using the National Physical Fitness Award (NAPFA) test battery that is used in all schools in Singapore (MOE, 2001). Four trained PE teachers who were certified to conduct the tests administered the tests over a period of two weeks during PE classes. The conduct of the physical fitness tests was in accordance with the guidelines outlined by the PE unit of the MOE in Singapore (MOE, 2001). Prior to the physical fitness tests, pupils were given two familiarisation sessions with the NAPFA test battery. The reliability of conducting the NAPFA test battery using trained and certified PE teachers is reported as high ($r=0.77$-0.93) (MOE, 2001).

Performance parameters measured in the NAPFA test battery were cardiovascular fitness (measured by a 1.6 kilometre run for pupils younger than 13 years of age or a 2.4 kilometre run for pupils aged 13 years or older); hamstring and lower back flexibility (measured by a sit-and-reach test), whole body speed and agility (measured by a 4x10 metre shuttle run), abdominal muscle endurance (measured by a 1-minute bent knee sit up), upper body endurance (measured by incline flexed arm-hang for girls and/or boys who were younger than 15 years of age or pull-up for boys aged 15 years or older) and power of lower limbs (measured by standing broad jump).

The timed run (1.6 or 2.4 km) was conducted on an outdoor 400m running track. Pupils were encouraged to complete the distance in as short a time as possible, by either running or a combination of running and walking. The test was terminated when the pupil crossed the finish line. Time elapsed for completing the run was recorded in minutes and seconds.

In the sit and reach test, pupils sat on the measuring apparatus that was equipped with a floating zero mark, which was adjusted for pupils' reach using both arms. Pupils' feet were placed shoulder-width apart and both thighs were secured with a Velcro strap to the apparatus to prevent any movement of the lower limb during the test. Pupils were instructed to reach as far as they could with the palms of both hands cupped together and pushing the marker as far away from the feet as possible in a single reaching action. The distance between the marker and the zero mark was measured to the nearest centimetre. The better of two attempts at the sit and reach was recorded.

In the shuttle run pupils ran a distance of 10 metres to a small block of wood, picked it up and returned to the starting line, repeating the shuttle three more times to pick up another block of wood 10 metres from the starting line. Pupils had two attempts at the test in the same test session. Time elapsed for completing the 4x10m shuttle run was recorded to the nearest tenth of a second.

For the bent-knee sit up test, pupils laid on their backs with knees flexed forming an angle of about 100 degrees with both feet placed flat on the ground and positioned shoulder-width apart. Arms were crossed over chest with hands placed on opposite shoulders. A partner held onto the pupil's feet, while the pupil curled to the sitting position, maintaining arm and chin contact with the chest. A sit-up was considered complete when elbows touched the thighs. The pupil's score was recorded as the number of sit-ups completed over 1 minute.

For girls and boys under the age of 15 the time taken in holding a flexed arm-hang position with the chin held above the bar was measured to the nearest second. For boys, the number of pull-ups over chin level performed over a 30-second period without thrusting of the lower limbs was recorded.

In the standing broad jump each pupil had two attempts at the jump in the same test session where the better effort for the distance jumped from a stationary position with feet positioned shoulder-width apart at take off was recorded to the nearest centimetre.

Points were awarded based on performance on each test item, norm-referenced for age and sex. The number of points accumulated determined the award given: Gold (21 points or more); Silver (15-20 points); and Bronze (6-14 points). No award was given when pupils accumulated less than six points.

HR monitoring

HR data, averaged over a minute, and monitored over a mean of 10 hours (0800 hours to 1800 hours), over two weekdays and one weekend day, were collected from a random sub-sample of 30 boys and 30 girls, using a HR monitoring device (Polar Vantage NV, Polar Electro Oy, Finland). Pupils wore the HR monitors (HRM) that consisted of a chest strap with wireless electrodes and a waterproof wristwatch

microcomputer. A leather cover was placed over the watch to help protect it from damage and to prevent pupils from tampering. The HR data, stored in memory for each pupil were retrieved the morning after and were downloaded onto an IBM-compatible computer by means of a POLAR computer interface.

The validity and reliability of ambulatory HR monitoring devices such as the Polar system have been reported elsewhere (e.g. Armstrong, 1998) and is widely accepted. Importantly, HR data using telemetric systems have been reported as valid with an error rate of only 2%.

The total time spent at HR intensities described physically inactive (HR<120 bpm), lightly active (HR 120-139 bpm), moderately active (HR 140-159 bpm) and vigorously active (HR>160 bpm), over the monitored period was summed to derive the accumulated time at the HR intensity. A HR of 146 beats per minute is reported to be equivalent to a brisk walk at 6 km per hour on a horizontal treadmill in a group of 40 young boys and girls (Armstrong and Welsman, 1997). The HR data over the two weekdays were averaged to derive a mean and median weekday value.

Statistical analyses

All data were stored in a computer and analysed using the SPSS for Windows version 10.0. Descriptive statistics (mean ± standard deviation) for physical characteristics of pupils, hours of computer use per week and the time spent at HR<120 bpm, HR 120-139 bpm, HR 140-159 bpm and HR >160 bpm were obtained. A descriptor of central tendency – the median – was used to describe hours of computer use per week and the total time spent at the four different HR ranges. Percentages were used to describe the responses of pupils to the questionnaire items in terms of physical activity and awards attained for physical fitness.

Relationships between hours of computer use, physical activity and physical fitness for primary and secondary school pupils were examined using Pearson Product Moment Correlation. Common variance between significant relationships was computed as r^2 X 100% (i.e. coefficient of determination).

To determine if male and female pupils, pupils at different academic levels (primary and secondary school pupils), and pupils with different physical activity levels differed in terms of awards attained for physical fitness and hours of computer use, a three (sex by academic level by physical activity) X two (awards for physical fitness by hours of computer use) multivariate analysis of variance (MANOVA) was used to compute the data.

Finally, a repeated-measures MANOVA was used to test the effects of academic level (primary school pupils vs. secondary school pupils) and days of the week (weekday vs. weekend day) on HR ranges (i.e. HR<120 bpm, 120-139 bpm, 140-159 bpm and HR>160 bpm). Statistical significance on all tests was accepted at $p<0.05$.

RESULTS

Descriptive statistics

The physical characteristics and questionnaire responses of pupils, organised by sex and academic level, are summarised in Table 1.

Table 1: Physical characteristics, hours of computer use, physical activity and physical fitness of primary and secondary pupils

	Primary school pupils		Secondary school pupils	
Variables	Boys (N=55)	Girls (N=65)	Boys (N=62)	Girls (N=58)
Age (y)	10.6±0.3	10.5±0.3	14.8±0.6	14.7±0.6
Body mass (kg)	34.4±6.8	33.6±6.9	57.9±10.9	48.5±5.6
Stature (m)	1.42±0.08	1.45±0.06	1.69±0.07	1.58±0.05
Questionnaire responses				
Previous computer experience (% of pupils)	98%		100%	
Access to computer (%)	98%		100%	
Use of computer (hr/wk^{-1})	6.0±5.0 (median 4.9)		8.6±7.7 * (median 6.0)	
Computer use for school-related work (hr/wk^{-1})	1.7±1.0 (median 1.0)		3.1±2.2 * (median 2.0)	
Computer use for leisure-related activity (hr/wk^{-1})	2.1±1.8 (median 1.0)		6.1±3.4 * (median 2.5)	
Physical activity classification (%)				
• Very light	22		26	
• Light				
• Moderate	37		36	
• Vigorous				

	31 10	30 8
Physical fitness awards (%) • Gold • Silver • Bronze • Nil	 30 32 34 4	 10 35 43 12

Values are means ± standard deviations

* Significant difference at $p<0.05$

Nine-eight to 100% of primary and secondary school pupils had previous experience using computers and had access to a computer, either in school or outside of school. Hours of computer use per week (6.0±5.0 vs. 8.6±7.7 hours, $p<0.05$) and hours of computer use for school-related work (1.7±1.0 vs. 3.1±2.2 hours, $p<0.05$) and for leisure and/or entertainment (2.1±1.8 vs. 6.1±3.4 hours, $p<0.05$) was significantly different between primary and secondary school pupils. Hours of computer use were significantly higher for secondary school pupils than primary school pupils.

In relation to physical activity, the distribution was not significantly different between primary and secondary school pupils. When the data were organised by sex, 16.3% and 31.7% of male pupils reported participating in very light and light physical activity, respectively. The corresponding values for female pupils were 28.4% and 45.5%. Thirty-nine point 4 percent of male pupils were moderately active while 22.7% of female pupils reported being moderately active. These were not significantly different.

Primary school pupils achieved three times the percentage of gold awards for physical fitness compared to secondary school pupils (i.e. 30% vs. 10%, $p<0.05$). Conversely, three times the percentage of secondary school pupils compared to primary school pupils did not receive any fitness award as they scored less than six points in the fitness tests (12% vs. 4%). This was significant at $p<0.05$ [$\chi^2(3) =14.15$].

Relationships between hours of computer use, physical activity and physical fitness

Table 2 shows the correlation matrix for relationships between hours of computer use, physical activity and awards given for physical fitness of primary and secondary school pupils.

Table 2: Correlation matrix for hours of computer use, physical activity and physical fitness of primary and secondary school pupils

	Hours per week of	Reported physical	Awards for

	computer use	activity	physical fitness
Hours per week of computer use	--	-0.14	0.12
Reported physical activity	0.23 *	--	0.18
Awards for physical fitness	-0.07	0.16	--

* Significant correlation coefficient at $p<0.05$

NB: Correlation coefficients established for primary school pupils are found in diagonal above while correlation coefficients in diagonal below are established for secondary school pupils. Pearson Product Moment correlations were run separately for primary and secondary school pupils.

There was a significant positive correlation between hours of computer use and physical activity for primary school pupils ($r=0.23$, $p<0.05$). However, the shared variance (i.e. coefficient of determination) was less than 6%. No other significant relationships were established.

MANOVA analysis

Results of MANOVA indicated that there was a significant multivariate effect in terms of sex, [Wilk's $\Lambda=0.947$, $F(2,164)=4.63$, $p < 0.05$, $\eta^2=0.05$], and academic level (i.e. primary school vs. secondary school) [Wilk's $\Lambda=0.907$, $F(2,164)=8.41$, $p<0.05$, $\eta^2=0.09$] for hours of computer use and for physical fitness. There was however, no main effect for physical activity and no significant ($p>0.05$) two-way or three-way interaction effects were detected.

Significant sex differences emerged from tests of between-subjects effects for physical fitness [$F(1,165)=9.46$, $p<0.05$, $\eta^2=0.04$]. Girls performed better than boys in the physical fitness tests and primary school pupils performed better in physical fitness tests than secondary school pupils [$F(1,165)=5.56$, $p<0.05$, $\eta^2=0.03$] (see Table 3).

Table 3: Hours of computer use, physical activity and physical fitness organised by sex and academic level

			Physical activity classification from questionnaire response			
Variable	Academic level	Sex	Very Light	Light	Moderate	Vigorous
Computer use (hr/wk)	Primary	Male	5.42±4.23	6.91±5.34	7.77±7.05	8.02±7.05
		Female	2.49±1.97	4.76±3.12	5.73±2.31	--
		Total	4.24±3.73	5.68±4.28	7.12±5.97	8.02±7.05
	Secondary	Male	8.45±6.24	13.85±12.28	9.61±11.53	5.10±4.05
		Female	11.80±12.67	8.14±6.14	9.71±11.50	4.50±4.77
		Total	10.96±11.34	10.99±9.99	9.64±11.30	4.90±4.00
Physical fitness	Primary	Male	2.17±0.72	2.20±0.86	2.58±0.96	2.43±1.13

		Female	1.88±0.99	1.70±0.80	1.89±0.78	--
		Total	2.05±0.83	1.91±0.85	2.36±0.95	2.43±1.13
	Secondary	Male	2.40±0.55	2.82±1.01	2.70±0.86	3.00±0.63
		Female	2.20±0.86	2.41±0.80	2.43±0.53	2.33±0.58
		Total	2.25±0.79	2.62±0.92	2.63±0.79	2.78±0.67

Values are mean±standard deviation

HR monitoring

Table 4 shows the median percentage of hours spent at the four HR ranges on two weekdays and one weekend day over an average of 10 hours for 60 primary and secondary school pupils.

Table 4: Median percentage of monitored time spent at the different HR intensities on weekday and weekend day for primary and secondary school pupils.

	Primary school pupils		Secondary school pupils	
Heart rate (bpm)	Weekday (%)	Weekend (%)	Weekday (%)	Weekend (%)
<120	86.3	96.1	94.0	99.5
120-139	9.7	3.8	4.3	0.5
140-159	2.4	0.1	0.9	--
>160	1.6	--	0.8	--

NB: HR descriptions: sedentary (HR<120 bpm); lightly active (HR 120-139 bpm); moderately active (HR 140-159 bpm) and vigorously active (HR>160 bpm).

The majority of pupils were physically inactive (HR<120 bpm), more so on a weekend day than on the weekday. For instance, for 98.7% (median value) of the time monitored on the weekend day pupils were mainly sedentary (i.e. HR<120 bpm) while for 90.2% (median value) of the time monitored on a weekday, pupils had HR<120 bpm. Conversely, all 60 pupils were physically more active at the light (HR 120-139 bpm), moderate (HR 140-159 bpm) and vigorous intensity (HR>160 bpm) on the weekday than on the weekend day.

Results of repeated-measures MANOVA showed that there were significant differences between primary and secondary school pupils at the sedentary, light, moderate and vigorous HR ranges (i.e. HR<120 bpm, 120-139 bpm, and 140-159 bpm) (Wilk's Λ=0.546, F(4,46)=9.55, p<0.05, η^2=0.45) as well as between weekday and weekend day (Wilk's Λ=0.306, F(4,46)=26.05, p<0.05, η^2=0.69), with primary pupils significantly less sedentary than secondary pupils. However, no sex or interaction effects were detected.

For the weekday, there were significant differences between primary and secondary pupils for time spent at HR<120 bpm (9.14±1.99 vs. 11.99±1.47 hr, p<0.05), HR 120-139 bpm (1.23±0.72 vs. 0.64±0.49 hr, p<0.05) and HR 140-159 bpm (0.34±0.24 vs. 0.14±0.11 hr, p<0.05) but not for HR>160 bpm (0.40±0.34 hr vs. 0.30±0.31 hr, p>0.05).

For the weekend day, there were significant differences between primary and secondary school pupils for time spent at HR<120 bpm (6.56±3.76 vs. 9.34±3.72 hr, $p<0.05$) and HR 120-139 bpm (0.44±0.55 vs. 0.18±0.41 hr, $p<0.05$) but not for HR 140-159 bpm (0.09±0.19 vs. 0.02±0.01 hr, $p>0.05$) and HR >160 bpm (0.04±0.11 vs. 0.01±0.01 hr, $p>0.05$).

None of the pupils from primary or secondary school accumulated any activity that was described as vigorous (i.e. HR>160 bpm) on the weekend day. Primary school pupils accumulated less than one minute of physical activity that was described as moderate intensity (i.e. HR 140-159 bpm) for the weekend day.

DISCUSSION

Physical characteristics of pupils

The physical characteristics-age – body mass and stature – of the pupils were comparable to other pupils in the same age groups in Singapore (School Health Service, 1993). All 240 pupils were considered to be healthy in relation to body weight for age and sex, according to the weight for height norms used by the School Health Services of the Ministry of Health in Singapore (School Health Service, 1993). In the present study, underweight and overweight pupils were excluded in order to investigate the relationships between hours of computer use, physical activity and physical fitness among pupils of healthy weight-height range.

Computer use and accessibility of computers

The results of this study showed that previous experience with using a computer and accessibility to a computer in school and outside school was pervasive among primary and secondary school pupils. According to information gleaned from the MOE website, for all schools in Singapore, the pupil-computer ratio is 2:1 (MOE, 2002). Moreover, it is reported that Singapore has the highest personal computer penetration for households in the Asia-Pacific region, including Australia and the USA (Infocomm Development of Singapore, IDA, 2000).

In terms of hours of computer use per week, the increase was significant between primary and secondary school (i.e. $p<0.05$). Primary and secondary pupils spent significantly more time on the computer for leisure and entertainment as for school-related work (see Table 1).

In a 1993 survey of children aged 6-18 years (N=730 boys, 849 girls) on youth coronary risk and physical activity in Singapore conducted by Schmidt, et al. (1998), pupils were grouped into five cohorts based on their self-assessment of physical activity (i.e. inactive, relatively no activity, light activity, moderate activity and vigorous activity). Based on questionnaire responses pupils spent an average of two hours (range=1.5-6 hours) daily on multimedia engagement (e.g. television and/or video watching and computer use). No differences were found between boys' and girls' groups in daily

hours of multimedia engagement, but girls in the vigorous activity group had significantly lower multimedia use than boys.

In the present study, information about time spent on watching television or videos was not collected but it is conceivable that hours of computer use in the present study would exceed that reported by Schmidt, et al. (1998). The cited study was conducted in Singapore in 1993, before the inception of the Singapore IT Master Plan for Education in 1997 (Kuo et al, 2002). It is conceivable that computer use and its accessibility were less widespread than that reported in the present study. Health educators (e.g. Chia et al, 2000; Chia et al, 2002) have voiced concern that as computer use for leisure and entertainment increase in pupils as they get older (see Table 1) the trade-off might be less engagement in physical activity and/or lower physical fitness.

Relationships between hours of computer use, physical activity and physical fitness

The results of the present study showed a weak but significant relationship ($r=0.23$, $p<0.05$) between hours of computer use per week and physical activity for primary school pupils. Moreover, there were no significant relationships ($p>0.05$) between hours of computer use, physical activity and physical fitness for primary and secondary school pupils (see Table 3). The lack of a significant relationship between physical activity and physical fitness was expected since physical activity describes lifestyle behaviour with many dimensions while physical fitness is an attribute with many different components (Chia and Quek, 2001).

Self reported physical activity versus HR monitoring data

With reference to questionnaire responses about physical activity, MANOVA results showed no main effects for physical activity. In other words, primary and secondary school pupils did not differ significantly in their self-reported physical activity. On the other hand, HR data on the weekday and weekend day showed that primary school pupils were significantly more active than secondary school pupils with less time spent at HR<120 bpm (see also Table 4).

Physical activity behaviour is complex and has many dimensions such as the type of activity, the duration and intensity of the activity, the frequency of the activity, the amount of caloric expenditure of the activity and the purpose of the activity (Chia and Quek, 2001). Very often, the measurement instrument of choice (e.g. questionnaire and heart-rate monitors) is unable to capture all the dimensions that describe behaviour that is associated with physical activity (e.g. type, duration, intensity, frequency, purpose or context of physical activity).

Therefore when different methods are used to collect data on physical activity of the same group of pupils, as was the case in the present study, it is difficult to compare the data since the different methods do not necessarily measure exactly the same aspect or dimension of physical activity. Sallis and Owen (1999) pointed out that

physical activity data garnered from questionnaire response tend to be higher than that estimated from HR monitoring. For example in the present study, both primary and secondary pupils reported engaging in vigorous physical activity but this was not corroborated by the HR data.

Sex difference in physical activity

The results of this study showed no difference between boys and girls for physical activity, either from questionnaire response or HR monitoring, a finding that is contrary to results of some studies, which show that girls are less active than boys between the ages of six and 18 years (Armstrong and Welsman, 1997; Gilbey and Gilbey, 1995; Sallis and Owen, 1999). However, the discrepancy in results between studies could be due to cultural and regional differences (Sallis and Owen, 1999), or might be attributed to the different methods that have been used to collect and classify physical activity.

The results of this study of no sex difference in physical activity is however supported by results of a study on 52 boys and 52 girls aged 13-14 years that used similar HR monitoring devices over three weekdays and a weekend day. Welsman and Armstrong (2000) reported that over weekdays and the weekend day, girls and boys did not differ in physical activity in terms of the percentage of time that was spent engaged in moderate to vigorous physical activity.

Physical fitness of pupils

The results of this study showed that primary school pupils were significantly fitter than secondary school pupils, based on the number of gold awards and number of pupils that did not receive any fitness award. Girls also performed significantly better than boys in the physical fitness tests (see Table 3). Other physical fitness data in Singapore has shown that girls achieve higher fitness awards than boys in physical fitness tests, especially in primary schools (Chia and Wang, in press).

In the study by Chia and Wang, the authors examined the relationships between physical self-worth, body weight satisfaction and physical fitness of 518 pupils (275 boys and 243 girls) aged between nine and 13 years old. It was reported that physical fitness scores improved significantly with age, but girls had significantly higher physical fitness points than boys even though no significant sex difference in perceived physical self-worth was detected.

Juxtaposing the findings on no sex difference in physical activity and better physical fitness in girls than in boys, from two separate studies conducted in Singapore by the same principal investigator, it could be inferred that at about 9-13 years old, girls are fitter than boys of the same age, and that boys and girls aged between 9 and 13 years do not mirror adults trends of physical activity where adult women are physically less active than adult men (National Health Survey, 1998).

HR of pupils

Results of HR monitoring based on 30 boys and 30 girls showed that a very high percentage of pupils were sedentary (i.e. HR<120 bpm), and significantly more pupils were sedentary on the weekend day than on the weekday.

Primary school pupils were significantly less sedentary than secondary school pupils for the weekday and the weekend day. The reasons why physical activity was less for the weekend day compared to the weekday need to be further investigated but the result mirrors the findings of others in studies conducted in Singapore (e.g. Gilbey and Gilbey, 1995; Lim, 1995) and in the UK (Welsman and Armstrong, 2000). It can be speculated that accessibility to environments that promote physical activity during weekdays (e.g. school) compared to the weekend (e.g. home and the community) might have a part to play in explaining the behaviours related to physical activity of participants.

Previous data on pupils from primary schools in Singapore has shown similar trends of physical inactivity (Gilbey and Gilbey, 1995), albeit the criterion upon which physical activity was classified is different between the studies. In the present study, total time *accumulated* at HR<120, HR 120-139, HR 140-159 and HR>160 bpm was used to describe physical activity whereas in the study conducted by Gilbey and Gilbey (1995), the total time that the HR was *sustained* at a HR>140 bpm for 5, 10 and 20-minute blocks was used to describe physical activity of pupils. In the present study, it is speculated that accessibility to environments that promote physical activity during the weekday (e.g. school) compared to the weekend (e.g. home and the community) might have a part to play in explaining the physical activity behaviour of pupils.

The results of this study showed that primary school pupils were less sedentary than secondary school pupils. Equivalent data, based on questionnaire responses and HR monitoring from UK (Welsman and Armstrong, 2000), USA (Sallis and Owen, 1999) and Europe (Van Mechelen and Kemper, 1995) show similar trends of declining physical activity patterns with age during the childhood and adolescent years. Van Mechelen and Kemper (1995) reported that in the Netherlands, physical activity of young people declined steeply between the ages of 13 and 16 years in boys and girls but less steeply between the ages of 16 and 27 years. However, it is not clear whether such a decline in physical activity with age in the growing years is due to biology or to social influences (Sallis and Owen, 1999) or is indeed a combination of the nature and nurture factors.

Health educators caution that childhood patterns of behaviour carry over into adulthood (e.g. Biddle *et al*, 1998; Welsman and Armstrong, 2000). It is therefore important to address the issue of declining physical activity and physical fitness with age

since adequate physical activity and improvements in physical fitness, especially cardiovascular fitness are associated with lowered risks of heart disease, stroke and certain forms of cancer in adults. These diseases are the three major causes of premature death in adults in Singapore (Chia et al, 2002). It is noted that in present study, the majority of primary and secondary school pupils were physically inactive (i.e. HR<120 bpm) for most of the time on the weekend day and the weekday. More remains to be done to encourage all pupils to be physically active everyday so that sedentary behaviour among pupils does not become entrenched in the present time and also in the future.

Physical activity recommendations

Guidelines for young people on the recommended physical activity have emerged from two Consensus Conferences, which while useful, reflect quite different approaches to the quality and quantity of desirable physical activity recommended for children and adolescents. More needs to be done to disseminate these recommendations to educators of pupils' health in schools, as despite being available for nearly a decade, they remain relatively unknown in Singapore (Chia and Quek, 2001).

The first recommendation from the International Consensus Conference on Physical Activity Guidelines for Adolescents (ICCPAGA) (Sallis and Patrick, 1994) is for adolescents to engage in three or more sessions per week of activities that require moderate-to-vigorous levels of exertion that last 20 minutes or more at a time. In 1996, the National Institutes of Health (NIH) Consensus Development Panel on Physical Activity and Cardiovascular Health recommended that "all children and adults should set a long-term goal to accumulate at least 30 minutes or more of moderate intensity physical activity, on most, or preferably all days of the week." (NIH, 1996).

HR data in the present study showed that neither primary nor secondary school pupils satisfied the criterion of accumulating 30 minutes of moderate intensity physical activity on the two weekdays and the weekend day. Primary school pupils managed to accumulate only 14 minutes of physical activity at the moderate intensity on the two weekdays, while secondary school pupils managed only five minutes at the same intensity over the same period.

Combined intensities of physical activity

Pate, Long and Heath (1994) suggested combining durations of light, moderate and vigorous physical activity intensities to arrive at a more complete picture of pupils' daily physical activity. In their literature review of physical activity studies they reported that in most studies that used the combined intensity approach to describe habitual physical activity, the median physical activity time was about 60 minutes a day. Applying the same method to HR data in the present study, primary school pupils accumulated 116 minutes on the weekday and 34 minutes on the weekend day. Corresponding values for secondary school pupils were 67 minutes for the weekday and 11 minutes for the weekend day.

It appears therefore that primary and secondary school pupils in Singapore had comparable amounts of physical activity on the weekday as reported in studies elsewhere (Pate, et al, 1994) but physical activity of primary and secondary school pupils on the weekend day was less than 60 minutes. Pupils in Singapore need to increase their physical activity especially on the weekend days by selecting more physically active behaviour and/pursuits rather than sedentary ones.

IMPLICATIONS FOR SCHOOLS

It is suggested that schools give greater license to students' play and movement about in the school environment as part of informal play (before school, during recess, and after school), as part of daily physical activity and physical education, as part of co-curricular activities, and as part of project or team work held outside a classroom setting. At the present time, there are schools that forbid play, in some combination of before, during and after school unless it is part of organised activity. In other words, justifications for free play or access to play are not accorded their rightful priority.

It is suggested that schools take action to make physical play more attractive than sedentary behaviours such as eating and excessive computer use by removing barriers for play. The Ministry of Education can ensure that schools provide safe play areas, good conditioned equipment, and ample daily opportunities for unstructured and structured play before, during and after school hours.

It is suggested that schools include an additional period of free play, per week during school hours as part of physical recreation where pupils can be given choice of a sporting pursuit that can carryover into adulthood e.g. small-sided soccer, basketball, badminton, table-tennis and aerobics.

If the trends of reduced physical activity and the curtailment of physical play in daily life are allowed to continue unabated, the future health & vivacity of Singaporeans may be compromised.

CONCLUSION

Nearly all pupils reported having had previous experience of and accessibility to a computer. Hours of computer use per week for secondary school pupils were significantly higher than for primary school pupils, as were the hours of computer use for leisure and/or entertainment than for school-related work. There were no significant relationships between hours of computer use, physical activity and physical fitness except for a small significant correlation between hours of computer use and physical activity in primary school pupils. There was no significant sex difference in physical activity but girls performed significantly better in tests of physical fitness than boys. Primary and secondary school pupils reported similar physical activity but primary school pupils were significantly fitter than secondary school pupils. HR data revealed that all pupils were significantly less sedentary (HR<120 bpm) on the weekday than on

the weekend day and that primary school pupils were significantly less sedentary than secondary school pupils on both weekday and weekend day. All pupils were insufficiently active physically especially on the weekend day with reference to recommendations for moderate-to-vigorous physical activity for children and adolescents. More can to be done to encourage all pupils to be physically active everyday and to improve on physical fitness as the future health and vivacity of Singaporeans might well depend on that.

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