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Associations between physical activity, screen time, and friends' social network in a sample of Greek-Cypriot primary school children

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ABSTRACT
Purpose. This study aimed to examine: (1) associations between children's physical activity, screen time, and their friends' respective behaviours, and (2) whether a child's popularity is associated with his/her physical activity and screen time.
Methods. Participants included 136 children (37.5% boys and 62.5% girls) with a mean age of 11.8 years. Children wore a pedometer for four weekdays to assess physical activity and completed a diary relating to the time spent in three screen time activities. They also nominated three friends for school and out-of-school hours.
Results. Bivariate associations between school physical activity and friends' physical activity ranged from $r = 0.27$ ($p < 0.05$) to $r = 0.47$ ($p < 0.05$) and for the whole day from $r = 0.27$ ($p < 0.05$) to $r = 0.40$ ($p < 0.001$). At the multivariate level, boys' and girls' physical activity was associated with the physical activity of their best friend, explaining 42% and 11%, respectively, of the variance for school, and 11% and 9% of the variance, respectively, for whole day physical activity. In the boys' analyses, time per day playing electronic games was associated with the child's popularity, explaining 42% of the variance.
Conclusions. Children's physical activity is associated with the physical activity of their best friends, while among boys, time playing electronic games is associated with their popularity. Targeting children's friendship networks may help promote physical activity for both boys and girls and may help reduce time spent on electronic games among boys.
Key words: pedometer, screen time, popularity, friendship network

Introduction

Consistent evidence links children's participation in physical activity (PA) with favourable cardiometabolic biomarkers, body composition, and bone health [1, 2]. At the same time, excessive engagement in screen time appears to negatively influence body composition, cardiometabolic risk factors, and behavioural conduct/pro-social behaviour [2, 3]. As youths begin to engage in insufficient levels of PA [4] and sedentary time appears to increase as early as 5–9 years of age [5], there is a need to identify those factors that influence these behaviours to promote children's health.

Friends are an important social influence on a child's PA from childhood to adolescence [6]. Research showed that friends can influence the child's PA through social norms and conversation (e.g. encouragement), friends' participation in PA (modelling), and participating in PA with friends [7]. Nevertheless, reviews recommended that more studies are warranted that collect data from children's friends, rather than the children's own perceptions and ratings of their friends' attitudes, beliefs, and behaviours [7].

Social network analysis allows researchers to obtain information from children's friends, through friendship nominations, whereby the participants indicate or nominate their friends [8, 9]. Thus, PA and sedentary behaviour data can be obtained directly from the nominated friends and does not rely on an individual reporting the behaviour of his or her friends [10]. For example, studies have asked children to nominate up to four of their closest school friends [11], or up to 10 or more friends [12, 13] and examined potential associations between the PA and the sedentary behaviour of the child and his/her friends' respective behaviours. Through friendship nominations, social network analysis attempts to explain behaviour by identifying connections or relationships a child might have throughout a network or a social context [9]. Understanding the relationship between PA and sedentary behaviour with

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friendship networks may help tailor intervention and improve a program's effectiveness [11, 13]. For example, a child that is physically active and more popular based on nominations received may play an important role in promoting PA to physically inactive children [12].

Social network studies have used different methods of PA assessment, including self-reports [12, 13, 14], accelerometers [11, 14, 15], and pedometers [10]. Results from these studies showed that the children's moderate to vigorous PA was associated with the PA of their friends [11], and adolescents' PA was similar to that of their friends than non-friends [15]. Gender differences were also observed, with some studies showing higher associations between a boy's than a girl's PA and their friends' behaviour [11], while other studies observed stronger associations between girls and their best friends' PA than for boys [10]. More data from different studies are needed to further explore possible gender discrepancies between PA and network variables.

Contradictory results were found in studies regarding a child's popularity, as measured by the number of nominations a child received, and its association with PA. Marks et al. [14] observed that self-reported PA was associated with having a higher number of friends, and Sawka et al. [16] found that adolescents who received no friendship nominations spent significantly fewer days per week achieving 60 minutes of moderate to vigorous PA compared to adolescents who received friendship nominations. On the contrary, Montgomery et al. [13] did not find any association between the number of nominations a child received and his/her PA level. The possible association between a child's friendship popularity and PA warrants further investigation, as studies using self-reports [12, 13, 16] and objective measures of PA [14] have produced conflicting results. Furthermore, while these studies examined the association between PA and the child's friendship network, they did not differentiate a friend's effects during different periods of the day, for example, school hours. It would be interesting for future studies to examine whether a child's popularity is associated with PA during different periods of the day.

A number of studies in Australia [14], Canada [16], the UK [11], and the US [17] have examined the association between friendship network characteristics and children's and adolescents' sedentary behaviour. One study did not show any association between children's weekday recreational screen time and their friends' behaviour [14], while the study by Sawka et al. [16] suggested that boys (but not girls) in high-density networks were more likely to be highly sedentary compared with boys in low-density networks. More recent evidence from the UK using accelerometers for assessing sedentary time showed that sedentary time was weakly associated with the children's friendship networks, with weaker associations observed among girls than boys [11]. These findings are in agreement with those of a study among children from the USA that indicated that boys' self-reported video game playing and girls' television watching were associated with their friends' respective behaviours [17]. The contrasting findings and limited number of studies that have examined a child's sedentary behaviour and screen time in relation to their friendship network and gender, point to the need for more studies to examine this relationship.

While a number of studies have examined children's PA and sedentary behaviour and their friendship network, these studies have been primarily conducted in developed countries, including the US [15, 17], Canada [10, 12, 16], Australia [14], the UK [11], and Northern Ireland [13]. More evidence from other countries from different parts of the world is needed to enhance these findings. While trends in PA and sedentary behaviour in Eastern Europe and the Middle East are comparable to those in other parts of Europe and North America [18], no studies have been conducted in this part of the world that examine these relationships. As children from Cyprus have been found to be the least active among children from eight European countries [19], there is a need to identify those factors that are associated with PA and sedentary behaviour to improve the effectiveness of potential interventions.

To extend previous findings relating to PA, screen time, and the children's friendship network, and enhance efforts to promote PA and reduce screen time among children in Cyprus, the present study aimed to: (1) examine possible associations between children's PA and screen time with their nominated friends' respective behaviours during the school hours and the whole day, and (2) investigate whether the child's popularity as indicated by the number of nominations received is associated with his/her PA and screen time.

Material and methods

Participants

A convenient sample of children in grades 5 and 6 from five schools in one town in Cyprus were invited to participate in this study. Parental consent forms were sent explaining the procedures of the study and a total of 136 children (47.3%) returned signed informed

consents. Fifty-one or 37.5% of the participants were boys, and 85 or 62.5% were girls, with a mean age of 11.8 years.

Instruments

Physical activity

Children's PA was measured for four school days using the DW-200 YAMAX pedometer (Yamax Corporation, Tokyo, Japan). Given the context of this study, the use of this pedometer is a feasible, easy-to-use, and cheaper alternative to more expensive monitors [20, 21]. Children were given a diary and recorded their steps during four consecutive weekdays. Four days of measurements provide reliable estimates of the children's PA behaviour [21–23]. Cronbach's α values for the four days of school hour PA and the four days of whole-day PA were 0.82 and 0.88, respectively, which, according to Trost et al. [22], are acceptable. Repeated measures ANOVAs did not show significant differences across the four days for both school-hour PA and whole-day PA, suggesting that reactivity was not an issue in our data [23]. As the purpose of this study was not to assess habitual PA, we chose to exclude weekends to reduce participant burden. Furthermore, previous research suggests that friends' support is not associated with children's weekend PA [24], and adolescents are more likely to spend time with friends from their school network during weekdays than during weekends [25].

Screen time

For the same four weekdays that children wore the monitors, they were also asked to note the daily time they spent in three screen time activities, including (1) watching television, (2) playing electronic games on the tablet, smart-phone, X-BOX, PlayStation, and (3) in front of the computer. Time spent in each of the three screen time activities was recorded on a scale with seven responses, including 'not at all', 'up to 30 minutes', 'up to one hour', 'up to two hours', 'up to three hours', 'up to four hours', and 'more than four hours'. Cronbach's α for the four days of television watching, four days of electronic games playing, and four days in front of the computer were 0.89, 0.90, and 0.83, respectively, which, according to Terwee et al. [26], are acceptable. While there are still no conclusive recommendations about the best available sedentary behaviour self-report [27], these instruments are important as they are inexpensive, easy to administer, and provide information relating to the type of sedentary behaviour [27, 28].

Friendship nominations

This study collected sociometric or whole network data, where each participant was asked to nominate his/her friends and each child's behaviour was measured, in contrast to egocentric data, where a child is asked to nominate his/her friends and also report their perception of the behaviour of their friends [29, 30]. Children were asked to nominate their friends with two questions. The first question asked children to write down the names of three of their friends that they hang out with the most when they are at school and then circle the name of the child that is their best friend. Previous studies that collected network data have also used up to three friendship nominations [31–33]. The second question asked children whether they hang around with any of their school friends during the out-of-school period. If the children responded 'yes', they were asked to write down the name(s) of their out-of-school friend(s). As screen time sedentary behaviour occurs mainly outside school hours, it was deemed appropriate to collect information on the children's out-of-school friend(s) with a separate question. During this process, children were supervised by their classroom teacher and two research assistants to ensure that they felt at ease to nominate their friends.

Procedures

Pedometers were given to the children on a Monday for familiarization [23], and were instructed to record their steps from Tuesday through to Friday (four weekdays). Pedometers were reset and worn at the waist in the morning before coming to school and removed at night before going to sleep (except when swimming or bathing). Children were given recording cards and recorded their steps three times per day. At the beginning and at the end of the school time, to obtain a measurement of PA during school hours (07:45–13:05), and just before they went to bed, to obtain a measure of PA during the whole day. For each day that they wore the pedometers, they were also requested to complete the diary relating to the time that they devoted to the three screen-based activities. Teachers and parents were asked to check at the start and the end of each of the four school days (teachers) and before going to sleep (parents) whether the children recorded their steps and their screen time. On Monday, when pedom-

eters were given to the children, they were also asked to nominate their school and out-of-school friends.

Data analysis

Means, standard deviations, frequencies, and percentages were used to describe the sample's characteristics. Analyses were conducted for the whole sample and boys and girls separately, as previous studies indicated that there are gender discrepancies in the association between PA, screen time, and network variables [10, 11, 13, 16, 17]. Children's school hour PA, whole day PA, and time spent on television, playing electronic games, and on the computer were computed by averaging the values they recorded across the four weekdays.

Independent variables included the child's best, second, and third friend's PA and screen time behaviours, and the child's popularity. Based on previous research [13], the child's friends' group PA and screen time behaviours were also computed (i.e. the mean behaviours of the child's nominated friends). To estimate each child's popularity, the incoming friend nominations a child received [12] were counted. For this study, two measures of popularity were derived: (1) Best friend popularity, which considered the number of children that nominated each child as their best friend, and (2) Friends' popularity, which considered the total number of nominations each child received.

After each child's data were matched with his/her nominated friends, bivariate associations using Pearson's r and Spearman's rho (for parametric and non-parametric data, respectively) were computed between each of the five dependent variables (school hours steps, whole day steps, min/day watching television, min/day playing electronic games, min/day in front of the computer) and the independent variables. Regressions were conducted, one for each dependent variable with predictors the variables that were significantly associated with the dependent variables at the bivariate level. To identify potential multicollinearity (i.e., strong correlations between two or more independent variables), values of tolerance and VIF were inspected, which, according to Field [34], should be well above 0.2 and well below 10, respectively. Additionally, as network measures are more likely to be intercorrelated [11], the Durbin-Watson test (a measure of autocorrelation) that examines whether adjacent residuals are correlated, was also computed, with values less than one or greater than three being a cause for concern [34]. IBM SPSS Statistics Version 29.0.2.0 (20) (IBM Software Group, Chicago, IL) was used for all analyses, and the significance level was set at 0.05.

Results

Out of the 136 children who participated in the study, complete four-day data were obtained from 123 or 90.4% of children for school hours PA, 125 or 91.9% of children for whole day PA, and from 111 or 81.6% of children for each of the screen time activities. All children circled as best friends the name of the child that they reported as friend 1, and therefore, friend 1 will be reported as best friend. Table 1 presents means and standard deviations for age, PA, screen time, and popularity across the whole sample and for boys and girls. The majority of the participants were girls (62.5%), and the mean age of the sample was 11.8 years. The maximum number of school-hours best friend nominations a child received were five, and the maximum number of nominations from all three friends were six. The respective values for the out-of-school hours were four and five. Overall (data not presented in Table 1), there were 309 friendship nominations for school hours, including 128 for best friend, 105 for friend 2, and 76 for friend 3. For the out-of-school hours, there were 138 friendship nominations, including 81 for best friend, 39 for friend 2, and 18 for friend 3.

Table 2 presents the bivariate associations between the two PA variables, the three-screen time variables, and the six independent variables (friend nominations and popularity) for the whole sample and boys and girls. For the whole sample, moderately significant positive associations were observed between school-hours PA and all four friend nomination variables ranging from $r = 0.31$, $p < 0.05$ for friend 3 to $r = 0.46$, $p < 0.001$ for best friends. For boys, moderately significant positive associations were observed between school hours PA and best friend PA ($r = 0.35$, $p < 0.05$) and friend 2 PA ($r = 0.47$, $p < 0.05$), while for girls, moderately significant positive associations were observed between school hours PA and best friend PA ($r = 0.36$, $p < 0.01$) and group friends PA ($r = 0.27$, $p < 0.05$). For whole-day PA, two significant positive associations were observed for the whole sample, for best friends, $r = 0.40$, $p < 0.001$ and group friends, $r = 0.27$, $p < 0.05$, while boys' and girls' whole-day PA was associated with their best friends' PA ($r = 0.37$ and $r = 0.33$, $p < 0.05$ respectively). For the whole sample, time per day watching television was negatively associated with the best friend's hours of television watching ($r = -0.34$, $p < 0.05$), while time per day in front of the computer was positively asso-

Table 1. Descriptive statistics for age, physical activity, screen time, and popularity across the whole sample, boys, and girls

	Whole sample (n = 136)			Boys (n = 51)			Girls (n = 85)		
	Mean (*SD*)	Min	Max	Mean (*SD*)	Min	Max	Mean (*SD*)	Min	Max
Age	11.8 (0.6)	10.8	13.7	11.7 (0.6)	10.8	13.4	11.8 (0.6)	10.8	13.7
School PA (steps)	7850 (1911)	3545	13143	8795 (1815)	4806	13143	7304 (1754)	3545	12428
Whole day PA (steps)	15803 (4785)	6981	29830	17945 (4890)	7296	29830	14555 (4280)	6981	28953
Watching television (min/day)	57.0 (51.1)	0	300	47.9 (42.6)	0	210	62.1 (54.9)	0	300
Time in front of the computer (min/day)	16.9 (29.9)	0	173	14.8 (31.9)	0	173	18.1 (28.8)	0	120
Electronic games playing (min/day)	35.5 (46.0)	0	240	48.4 (59.3)	0	240	28.3 (35.0)	0	180
School popularity (best friend)[a]	1.4 (0.8)	1	5	1.5 (1.0)	1	5	1.4 (0.7)	1	4
School popularity (all friends)[b]	2.6 (1.4)	1	6	2.9 (1.5)	1	6	2.5 (1.4)	1	6
Out of school popularity (best friend)[c]	1.3 (0.6)	1	4	1.4 (0.8)	1	4	1.2 (0.5)	1	3
Out of school popularity (all friends)[d]	1.7 (1.0)	1	5	1.8 (1.1)	1	5	1.6 (0.9)	1	4

PA – physical activity
Number of nominations received: [a] as a best friend during school; [b] from all three friends during school; [c] as a best friend during out-of-school hours; [d] from all three friends during out-of-school hours

Table 2. Bivariate associations between physical activity, time per day watching television, computer use, playing electronic games (dependent variables), and friend nominations and popularity (independent variables) across the whole sample, boys, and girls

	Best friend	Friend 2	Friend 3	Group friends	Popularity (best friend)	Popularity (group friends)
Whole sample						
School PA	0.46***	0.33**	0.31*	0.42***	0.06	–0.04
Whole day PA	0.40***	0.09	–0.19	0.27*	0.17	–0.00
TV watching	–0.34*	0.21	–0.29	–0.20	0.04	–0.04
Computer use	0.28*	0.27	0.16	0.20	–0.14	–0.06
Electronic games	–0.13	0.01	–0.28	–0.05	0.31*	0.11
Boys						
School PA	0.35*	0.47*	0.21	0.29	–0.05	–0.07
Whole day PA	0.37*	0.11	0.37	0.23	0.13	–0.01
TV watching	–0.41	0.13	–0.69	–0.37	0.34	0.24
Computer use	0.14	–0.48	0.79	–0.11	–0.35	–0.16
Electronic games	–0.11	–0.31	–0.71	–0.13	0.67**	0.12
Girls						
School PA	0.36**	0.14	0.08	0.27*	0.08	0.13
Whole day PA	0.33*	–0.04	–0.69	0.18	0.11	0.10
TV watching	–0.28	0.23	–0.54	–0.10	–0.15	–0.18
Computer use	0.57*	0.25	–0.31	0.23	0.01	0.01
Electronic games	–0.25	0.18	–0.19	–0.13	0.29	0.08

PA – physical activity, TV – television
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

Table 3. Regression analysis results of school and whole day physical activity (steps), and minutes per day watching television, in front of the computer, and playing electronic games, and the independent variables across the whole sample, boys, and girls

	Whole sample			Boys			Girls		
	β[a]	*t*-value	*p*-value	β[a]	*t*-value	*p*-value	β[a]	*t*-value	*p*-value
Model 1 – School PA									
Best friend PA	0.516	5.007	0.000	0.514	2.989	0.008	0.346	2.364	0.021
Friend 2 PA	0.098	0.901	0.371	0.345	2.007	0.059	–	–	–
Friend 3 PA	0.169	1.567	0.122	–	–	–	–	–	–
Group of friends PA	–	–	–	–	–	–	0.024	0.167	0.868
	$F(3,63) = 12.075$, $p < 0.001$ Adjusted $R^2 = 0.34$			$F(2,19) = 8.525$, $p < 0.01$ Adjusted $R^2 = 0.42$			$F(2,70) = 5.278$, $p < 0.01$ Adjusted $R^2 = 0.11$		
Model 2 – Whole day PA									
Best friend PA	0.668	3.239	0.002	0.369	2.099	0.045	0.329	2.388	0.021
Group of friends PA	–0.305	–1.479	0.143	–	–	–	–	–	–
	$F(2,76) = 8.718$, $p < 0.001$ Adjusted $R^2 = 0.17$			$F(1,28) = 4.406$, $p < 0.05$ Adjusted $R^2 = 0.11$			$F(1,47) = 5.702$, $p < 0.05$ Adjusted $R^2 = 0.09$		
Model 3 – Television watching									
Best friend television watching	–0.330	–2.616	0.011	–	–	–	–	–	–
	$F(1,56) = 6.846$, $p < 0.05$ Adjusted $R^2 = 0.09$								
Model 4 – Computer use									
Best friend computer time	0.300	2.351	0.022	–	–	–	0.292	1.829	0.076
	$F(1,56) = 5.526$, $p < 0.05$ Adjusted $R^2 = 0.07$						$F(1,36) = 3.344$, $p = 0.076$ Adjusted $R^2 = 0.06$		
Model 5 – Electronic games									
Popularity (best friend)	0.510	4.271	0.000	0.674	3.760	0.002	–	–	–
	$F(1,52) = 18.24$, $p < 0.001$ Adjusted $R^2 = 0.25$			$F(1,17) = 14.137$, $p < 0.01$ Adjusted $R^2 = 0.42$					

PA – physical activity, [a] standardized coefficient

ciated with the best friend's time per day in front of the computer for the whole sample ($r = 0.28$, $p < 0.05$) and for girls ($r = 0.57$, $p < 0.05$). Time per day playing electronic games was positively associated with best friend's popularity for the whole sample ($r = 0.31$, $p < 0.05$) and for boys ($r = 0.67$, $p < 0.01$).

Table 3 presents the results of regression analyses for the whole sample and for boys and girls. Predictor variables included those that were significantly associated with the dependent variables at the bivariate level. Values of the Durbin-Watson test ranged from 1.7 to 2.4 that are not a cause for concern for correlations between adjacent residuals. The inclusion of all four variables in the school PA model for the whole sample showed evidence of multicollinearity as the tolerance values were below 0.2 and VIF values above 10. An inspection of the bivariate associations revealed that the variable group friends PA was highly associated with the other three variables (r values ranging from 0.755 to 0.811), and was therefore removed from the analysis. The new analysis revealed that the only variable that remained significant in the model was the best friend's PA ($\beta = 0.516$, $p < 0.001$), with the variables explaining 34% of the variance of the dependent variable. Best friend PA was also the only variable that remained significant in the boys' model ($\beta = 0.514$, $p < 0.01$) and girls' model ($\beta = 0.346$, $p < 0.05$), with the variables explaining 42% and 11% of the variance, respectively.

Similar results were obtained in the whole-day PA analyses, with the best friend's PA being statistically significant in the whole sample model ($\beta = 0.668$, $p < 0.01$) in the boys' ($\beta = 0.369$, $p < 0.05$), and in the girls' ($\beta = 0.329$, $p < 0.05$) models explaining 17%, 11%, and 9% of the variance respectively.

The variable best friend's television watching (β = –0.330, $p < 0.05$) explained 9% of the variance in the whole sample model predicting television watching, and the variable best friend's time in front of the computer (β = 0.300, $p < 0.05$) explained 7% of the variance in the whole sample model predicting time in front of the computer. The variable best friend popularity for the whole sample (β = 0.510, $p < 0.001$) and for the boys' model (β = 0.674, $p < 0.01$) explained 25% and 42% of the variance, respectively, in the variable time per day playing electronic games.

Discussion

This study examined the possible associations between a child's PA and their friends' PA during school hours and throughout the whole day. For boys, significant associations were observed at the bivariate level in school PA with the child's best friend and second friend, while for girls a significant association was observed for best friend, with coefficients ranging from 0.35 to 0.47. For whole-day PA, associations were only found for best friends and were 0.37 for boys and 0.33 for girls. Associations observed in the present study are comparable to those of Montgomery et al. [13], whose findings ranged from 0.40 for boys to 0.28 for girls. In accordance with previous studies [11, 13], analyses for the whole sample and for girls showed that at the bivariate level, children's PA during school hours was significantly associated with the PA of their group of friends (mean activity of all three children). The significant associations observed among children from different studies across different countries, using different measures of PA, strengthen the evidence that a child's PA is associated with their friends' PA and that active children are more likely to have active friends.

In the multivariate models, only the PA of the best friend remained statistically significant in the whole sample and the gender-specific analyses. It should be noted that while in a different study, the authors have included the best friend in the friend group variable [13], we chose to remove it from the whole sample analyses for school hours, as it showed evidence of multicollinearity. It may be that the moderate bivariate association observed with the friends' group PA is mostly attributed to the PA of the best friend. Percentages of variance explained in the multivariate models were 42% and 11% for school hours and 11% and 9% for the whole day in boys and girls, respectively. The higher percentage of variance observed for boys, especially during school hours, may supplement findings from a study conducted in the UK [11] that found correlations between friends to be stronger for boys than for girls. This may reflect the higher PA levels observed in boys than girls [18], who are more active when with friends, and girls prefer smaller facilities for 'hanging out' whereas boys primarily prefer activity-promoting facilities [35]. The higher percentage of variance explained in the school hours model in comparison to the whole day model suggests that best friends may be more influential during school hours, and other factors, such as family influences and sports club attendance may be more influential on whole day PA. Additionally, nominations in our study included only friends within the school, and children during the rest of the day may have different friends that were not captured in this study. Furthermore, the 40-minute total break time allocated to schools in Cyprus is more likely to bring children together in the confined school playground, and thus help them exhibit more similar behaviour than during the out-of-school hours. Our findings suggest that facilitating time spent with a child's best friend, particularly during school hours, and providing PA opportunities with friends may further promote PA levels in children.

While our study found associations between a child's PA and the behaviour of his/her friends, particularly their best friend, no associations were detected between a child's popularity as a best friend or among his/her group of friends. Our findings are in agreement with studies using self-reports of PA among 12-year-old children from Canada [12] and 14-year-old children from Northern Ireland [13], but are in contrast with findings from another study among children 11 to 15 years of age from Canada [16] that found that more popular boys and boys who had at least one friendship nomination were more physically active. These tendencies were not observed among girls. The lack of association in our study may be attributed to the fact that children were asked to nominate up to three friends. Nominating more than three friends would create a wider network and could potentially explore this issue further. Our findings suggest that a child's popularity or incoming friendship nominations is not associated with PA, and being more or less popular is not associated with PA participation. Nevertheless, as results from different studies relating to a child's popularity and PA participation are contradictory, more research is needed to further explore this association.

The only significant association observed relating to popularity was between best friend popularity and time per day playing electronic games on tablets, smart-

phones, X-BOX, or PlayStation for the whole sample and boys-only analyses. This finding is contrary to the findings of Sawka et al. [16] who did not find any associations between the total number of nominations a child received (popularity) and time reported spent on different screen devices. In the multivariate analysis, the child's popularity accounted for 25% and 42% of the variance of time per day engaging in electronic games for the whole sample and for boys, respectively. The lack of association in the girls' analyses, may reflect the finding that boys spent more time playing video games than girls [36], and that this behaviour may occur with friends. This finding may suggest that targeting a boy's best friends based on popularity may be an effective strategy to reduce screen time exposure, especially behaviours that relate mostly to electronic games. If there is a trend that more popular boys (nominated as best friends) are likely to be higher users of screen devices, particularly electronic games, causes of concern are raised, as evidence suggests that there is a rise in time spent playing video games and using computers among children [36] and screen exposure seems to be adversely associated with health [37]. While this finding is interesting, more evidence from larger studies adequately powered to test for possible gender interactions are required to confirm our results [38].

Two further findings in our study are worth discussing, relating to time spent in front of the computer and television. In the whole sample analyses, a small association was observed between time spent in front of the computer and best friend's time, with this variable explaining 7% of the variance. While in the girls' analyses, the bivariate association between time spent in front of the computer and their best friend's time was significant, this was not evident in the regression model. Unfortunately, the item used to measure time in front of the computer did not explicitly assess the type of activity or whether network connections were available that could explain possible online communication or online gaming between best friends. To advance knowledge in the field, future studies should put less emphasis on measures that aggregate screen use, and focus on content, context, and environment in which the behaviour takes place [37].

A counterintuitive finding of our study was that, for the whole sample, a child's time spent watching television was inversely associated with the time per day spent watching television by their best friend, with this variable explaining 9% of the variance in television watching. As television watching probably appears mainly in the child's house, it may be that parents and siblings have more influence on the time that children spend watching television than their friends. For example, a study suggests that friends may have an influence on what children are watching rather than the time that they spend watching television, and friends may have more influence on a child's behaviours, such as remote online gaming [39]. Furthermore, as television is mainly an out-of-school behaviour, the fewer peer nominations obtained in this study for the out-of-school hours may not have provided a clear picture of this association. Lack of associations between a child's and friends' television watching and time in front of the computer in the gender-specific analyses, may reflect the finding that both boys and girls spent a similar amount of time on these two screen devices [36] and that friends are not as influential in time spent on these devices as other individuals.

When interpreting the findings of this study, a number of limitations should be acknowledged. Firstly, the cross-sectional design of this study prevents us from inferring cause and effect relationships, that is, we cannot conclude that friends influence a child's behaviour or that children are friends with those that have similar behaviours. Secondly, pedometers cannot assess activities such as cycling and swimming and do not provide information relating to the intensity of the activity, while more valid evidence is needed for self-report questionnaires to assess screen time [27, 28]. The use of more objective measures, such as accelerometers, would provide more valid data [27]. Thirdly, the small and uneven sample sizes from a single town in Cyprus limit the generalizability of the findings, and future studies with balanced designs and larger samples to test for gender interactions and to account for boys' and girls' biological maturation [40] are needed to extend our findings. Fourthly, friend nominations in this study were only limited to three children and were collected from school friends, and children's out-of-school PA and screen time behaviour may be more influenced by friends that do not attend the child's school (i.e. out-of-school friends) and were thus not captured in this study. Finally, assessing PA during physical education lessons or extra-curricular activities, and extending PA and screen time measurements to the weekends, would provide a more complete picture of the associations between PA, screen time behaviour, and a child's social network. Nevertheless, this study was conducted in a unique population, providing evidence of associations between a child's PA and screen time behaviour and their friends' social network, which may help enhance existing literature.

Conclusions

Findings from this study suggest that a child's PA level is associated with the PA levels of their friends' social network, particularly of their best friend. Intervention programs that aim to promote childhood PA may consider targeting the boy's and girl's social network, particularly best friends, by facilitating and creating opportunities for co-participation. In the Cypriot context, this strategy may be more effective in the context of school, particularly among boys, as the strength of association was higher among boys than girls. As the popularity or number of nominations a child received (as a best friend) was associated with the boy's daily time spent playing electronic games, a social network approach for intervention programs that targets not only the child, but the child's social network, particularly the most popular friend, may help further reduce the boy's time spent on electronic games. To help improve the effectiveness of intervention programs, future studies may examine different aspects of children's friendship networks across specific PA periods and screen devices.

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Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Centre of Educational Research and Evaluation of the Cyprus Ministry of Education, Sport and Youth (approval No.: 186695).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Conflict of interest

The authors state no conflict of interest.

Disclosure statement

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