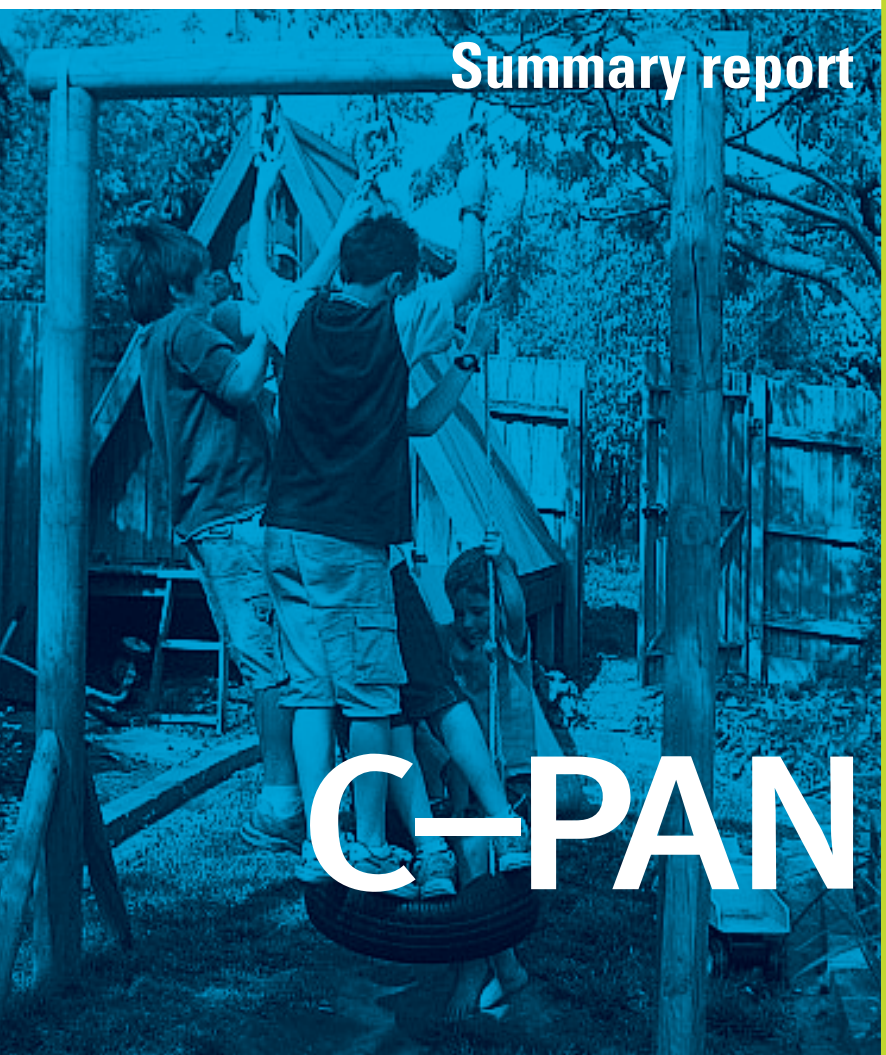
Deakin University

Children's and adolescents' physical activity during the critical window

Centre for Physical Activity and Nutrition Research

Summary report



C–PAN

Jenny Veitch
Verity Cleland
Jo Salmon
Clare Hume
Anna Timperio
David Crawford

DEAKIN UNIVERSITY

Children's and adolescents' physical activity during the critical window

Summary report

Centre for Physical Activity and Nutrition Research

Jenny Veitch Verity Cleland Jo Salmon Clare Hume

Anna Timperio David Crawford

Contact details for further information:

Dr Jenny Veitch
Centre for Physical Activity and Nutrition Research
Deakin University
221 Burwood Hwy
Burwood, Vic 3125
Email: jenny.veitch@deakin.edu.au
www.deakin.edu.au/cpan

Acknowledgements

C-PAN gratefully acknowledges the funding provided by the National Health and Medical Research Council to conduct this project. Thanks are also extended to the Victorian Health Promotion Foundation, which provided additional support for analysis and dissemination of project findings.

Particular thanks goes to all the children, adolescents and families involved in the project, as well as to the schools, principals and teachers who provided their support.

The contributions of the following staff are also acknowledged: Dr Nick Andrianopoulous, Dr Michelle Jackson, Anna Sztendur, Rebecca Roberts, David Attard, Leah Galvin and Julie Rankine.

Anna Timperio is supported by a Victorian Health Promotion Foundation Public Health Research Fellowship; Jo Salmon is supported by a Heart Foundation Career Development Award; and David Crawford is supported by a Victorian Health Promotion Foundation Senior Research Fellowship.

Contents

List of figures

List of tables

Executive summary

For young people, the time between the end of the school day and 6pm appears to be an important period for participation in physical activity and is often referred to as the 'critical window'. Initiatives that focus on this time period are therefore likely to be important in terms of promoting physical activity amongst children and adolescents.

This study sought to achieve greater understanding of the nature of children's activity during the critical window and the factors influencing it, in order to inform future promotional efforts. In particular, the study examined relationships between the family environment and physical activity during this period.

The study was a longitudinal design involving parents and children in metropolitan Melbourne over a five-year period from 2001 to 2006. In 2001, 1,196 parents were surveyed regarding their family demographics, their own participation in physical activity, family-based activities, and social support and reinforcement of their child's physical activity.

Physical activity of children participating in the study was objectively measured using accelerometers, which enabled estimation of the amount of activity and the intensity of the activity at different times of the day.

Findings of the study confirm the importance of this period for children's physical activity. It was found that the critical window period accounted for approximately 25% of total daily time spent in moderate-to vigorous-intensity physical activity (MVPA) across all age groups and sexes for the five years.

The time spent in MVPA during the critical window was also found to make an important contribution to children and youth meeting the recommended guidelines of 60 minutes of MVPA per day.

Reflecting the overall decrease in physical activity commonly observed as children get older, the younger age group spent almost twice the amount of time in MVPA during the critical window compared to the older age group.

The amount of time engaged in MVPA during the critical window declined by over 50% over the five years of the study. This decline was observed for both the younger (from 60 to 30 mins/day) and older (from 30 to 15 mins/day) age groups. These declines are consistent with previous research examining overall physical activity patterns, and highlight the need for strategies to encourage and assist children and youth to continue participation in physical activity as they get older.

Aspects of the family environment were found to influence participation in physical activity during the critical window. In particular, the findings emphasise the importance of role modeling, as well as the value of positive reinforcement and parent co-participation in physical activity. They suggest that targeting physical activity of other family members may have important benefits for both youth and adult health. Encouraging fathers to praise their sons' involvement in physical activity also appears to be an important strategy to consider for future programs and research. Among girls, having a family member to be active with, rather than simply observing or receiving support or praise from other family members, may also be important for promoting physical activity.

Findings from this study will help guide development of strategies to promote physical activity among children and adolescents, and suggest that future research and programs should focus on the critical window as this is a time when youth participate in substantial amounts of physical activity.

This report describes the key findings of the study. It will be of interest to parents and families of children and adolescents; teachers and schools; urban planners and policy makers; health professionals; and others interested in children's and adolescents' health.

Background and study aims

1.1 The importance of physical activity in childhood

Physical activity has been shown to be important for children's current and future health. Children who are highly active have more favourable cardiovascular risk profiles and bone health, as well as leaner body mass and enhanced psychological and psychosocial well-being [1,2]. Rising levels of childhood obesity [3] and an increased incidence of type 2 diabetes and other diseases of sedentary living [4], provide further support for investigating children's physical activity.

National guidelines for children's physical activity recommend that they perform at least 60 minutes of moderate-to vigorous-intensity physical activity (MVPA) every day [5]. The types of activities typically classified as of moderate-to vigorous-intensity include, for example, brisk walking, using playground equipment, and playing netball or football. Recent studies have shown that participation in MVPA decreases significantly between ages 9 and 15 years [6].

1.2 What are the opportunities for children's physical activity during the school day?

Opportunities for children's physical activity include structured and unstructured activities. Structured activities include participation in organised sport, physical education at school or sports classes at school. Unstructured activities may include walking or cycling to school, or free-play such as jumping on the trampoline in the backyard.

On weekdays, a child's school day comprises: non-discretionary time, which is when they are at school and (apart from school physical education or sport, and

recess and lunch breaks) they typically cannot choose whether to be active; and leisure or discretionary time, which is the time before or after school. During their discretionary time children may have the opportunity to participate in activities such as organised sport or free-play.

1.3 What is the critical window?

Studies have shown that on weekdays, the after-school period is when children perform the majority of their daily physical activity[7], and thus appears to be a critical period for participation in physical activity among young people[8,9]. This time frame between the end of the school day and 6pm is therefore known as the 'critical window'. For example, in a number of studies, after-school physical activity represented approximately half of the children's total daily physical activity, as measured by the number of steps taken, regardless of the child's sex[7,10].

Consistent with data for overall activity, boys and younger children are reported to be more active in the after-school period than girls and older children[11]. Other studies have found that boys tend to be more active in the after-school period than girls, and that girls are more active during school time than boys[8].

Very few studies have, however, focused on the daily patterns of MVPA during weekdays, and the influences on participation in MVPA with respect to specific time periods throughout the day[8]. Additionally, few studies have explored how physical activity during the critical window changes over time, or the contribution that these changes make to overall physical activity as children get older.

1.4 How does the family environment influence physical activity?

The family environment provides an important setting that may nurture, support or constrain physical activity among youth[2]. Family ethnicity has been shown to be associated with physical activity among Australian youth, with participation in after-school activity higher among children with parents born in Australia, or when English is the main language spoken at home[12].

Other factors within families that have been shown to be positively/directly associated with youth physical activity include parental modelling of physical activity behaviours (e.g. displays of physical activity participation)[13] and parental support for physical activity (e.g. taking the child to sports practice and providing encouragement and praise for participating in physical activity)[14].

As children grow and mature into adolescence, however, they may have different priorities and increased independence, and they may place less importance on parents' views and encouragement to be active. The association between parental physical activity and youth physical activity appears stronger among children than adolescents[14], however, little is known about how these and other family factors influence children's and adolescents' physical activity over time.

The influence of parents and siblings is likely to be more applicable to activity performed outside of school hours when the family environment may be expected to have the most influence.

1.5 Study aims

In light of the gaps in knowledge identified above, this study sought to examine patterns of physical activity during the critical window. In particular it aimed:

1. To examine children's and adolescents' participation in MVPA during the critical window, and how this participation changed over a five-year period; and
2. To examine how the family environment may influence children's and adolescents' participation in MVPA during the critical window over time.

Study design and methods

2.1 Study design

This longitudinal study examined weekday physical activity during the critical window, which was defined as the period after school until 6pm. It also examined the relationships between the family environment and physical activity during the critical window over a five-year period.

The study involved:

- objective measurement of children's and adolescents' MVPA during the critical window in 2001, 2004 and 2006; and
- parent reports (in 2001) of their family demographics, their own participation in physical activity, family-based activities, and social support and reinforcement of their child's physical activity.

Approval to conduct all phases of this study was received from the Deakin University Human Research Ethics Committee, from the Victorian Department of Education and from the Catholic Education Office. Consent for participation in the study was provided by the parents on behalf of themselves and their child.

2.2 Study participants

Children and their parents were recruited to the Children's Leisure Activities Study (CLASS) in 2001 from ten primary schools in the eastern suburbs (high socioeconomic status (SES)) and nine primary schools in the western suburbs (low SES) of Melbourne, Australia. All children aged 5-6 years and 10-12 years, and their parents, were eligible to participate in the study. Numbers of participants are outlined in Table 1. Participants in CLASS in 2001 were then re-contacted in 2004 to be part of the follow-up study (Children Living in Active Neighbourhoods, or CLAN), and again in 2006.

In 2001, participants were:

- Primary schoolchildren in grade prep (age 5-6 years) and grades 5-6 (age 10-12 years)
- Parents of these children

In 2004, participants were:

- Primary schoolchildren in grade 2 (age 7-8 years)
- Secondary schoolchildren (adolescents) in years 7-10 (age 12-15 years)

In 2006, participants were:

- Primary schoolchildren in grade 4 (age 9-10 years)
- Secondary schoolchildren (adolescents) in years 9-12 (age 15-18 years)

Table 1 Study participants in 2001, 2004 and 2006

	CLASS	CLAN	
	2001	2004	2006
Younger children	259	182	163
Older children	879	302	227
Parents	1196		

2.3 Objectively-measured physical activity

Physical activity was objectively measured using a Manufacturing Technology Incorporated (MTI) Actigraph accelerometer. Accelerometers allow researchers to estimate the amount of activity, as well as the intensity of that activity performed, at different times of the day.

Participants in this study were requested to wear an accelerometer for eight consecutive days in order to measure their habitual physical activity. These devices were worn on the right hip and measured intensity, frequency and duration of movement. A formula was then applied to calculate average minutes/day of MVPA after school until 6pm (i.e. during the critical window)[9].

2.4 Parent's survey — the family physical activity environment

Family demographics

Parents reported their marital status, the number of other children aged under 18 years living in the house, and highest level of maternal education (self-reported by mothers/female carers or proxy-reported by fathers/male carers).

Physical activity modelling

Parents reported the usual duration of their own and their partners' (if applicable) physical activity for a typical week. Participants reported separately for walking, moderate (e.g. walking the dog, gardening, golf, lap swimming) and vigorous intensity (e.g. tennis, jogging, cycling) physical activities. In accordance with adult physical activity recommendations[15,16,] parents achieving at least 150 minutes/week over five sessions were categorised as 'meeting guidelines'. All others were classified as 'not meeting guidelines'. Parents reported how frequently other children in the family ('think about the most active one') participate in physical activity, such as organised sport, walking for exercise, cycling or swimming. Responses were scored: don't know/doesn't apply (0), never (0), <once/wk (0.5), 1-2/wk (1.5), 3-4/wk (3.5), 5-6/wk (5.5), daily (7).

Family participation in physical activity

'Co-participation' in physical activity was assessed by asking participants how often the father, mother and other siblings ('think about the one who participates the most with your child') actively participated in physical activity with the child (e.g. go cycling or walking together, have a hit of tennis together; not just supervising the child while he/she is being active). Responses were scored separately as above.

'Family-based activities' were assessed by asking parents how often they go for bike rides, go swimming, go to the park, walk the dog, walk for fitness, or play sport together as a family with at least one adult family member. Responses to each item were scored: don't know/doesn't apply (0), never/rarely (0), 1-2/month (0.5), 1/wk (1), several times/wk (3.5) or daily (7).

Direct support for physical activity

Participants were asked how often the mother and father, respectively, provided 'direct support' (e.g. take him/her to training, provide money for participation, buy sports clothing/equipment) for their child's participation in physical activity. Responses were scored: don't know/doesn't apply (0), never (0), <once/wk (0.5), 1-2/wk (1.5), 3-4/wk (3.5), 5-6/wk (5.5) or daily (7).

Reinforcement of physical activity

Parents were asked how often the mother and father, respectively, praised the child for participating in physical activity. Responses were scored: don't know/doesn't apply (0), never (0), <once/wk (0.5), 1-2/wk (1.5), 3-4/wk (3.5), 5-6/wk (5.5), daily (7).

Study findings

3.1 Characteristics of study participants

Table 2 shows the characteristics of the children and adolescents that participated in the CLASS study in 2001. Younger children were aged approximately 6 years and older children/adolescents were aged approximately 11 years. The majority of parents in the study were married and, on average, had 1.5 other children aged less than 18 years living in the house. Maternal education, which is commonly used as an indicator of family-level socioeconomic position varied, although more than one-third of mothers had university/tertiary education.

Table 2 Family characteristics of children and adolescents, 2001

	Children		Adolescents	
	Boys (n=131)	**Girls (n=129)**	**Boys (n=402)**	**Girls (n=474)**
Child age (mean years)	6.1	6.1	11.5	11.4
Parental marital status (%)				
Married	79.4	76.0	75.4	74.9
Defacto/living together	5.3	8.5	4.7	6.1
Separated/divorced	10.7	9.3	16.2	15.6
Widowed	0.8	0	0.7	0.6
Never married	3.8	6.2	3.0	2.7
Number of other children aged <18yrs living in the house (mean)	1.47	1.47	1.44	1.45
Maternal education level (%)				
Some high school or less	25.2	22.0	27.6	31.5
High school or technical cert.	33.9	37.8	39.3	34.5
University/tertiary	40.9	40.2	33.2	34.1

3.2 Physical activity and the critical window

Key findings:

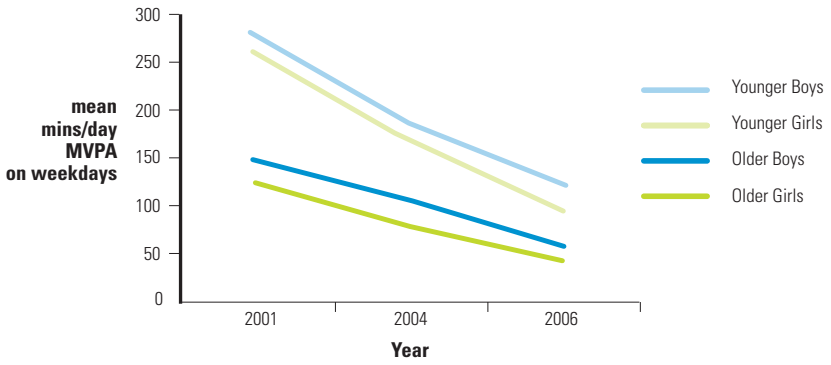
- **Children in the study performed approximately 25% of their total daily physical activity (MVPA) during the critical window across the five years. This was true for both age groups and sexes.**
- **The critical window made an important contribution to children and adolescents meeting the recommended guidelines for physical activity (60 minutes per day).**
- **The amount of time engaged in MVPA declined as children got older, both overall as well as during the critical window.**
- **For younger children, the decline in MVPA during the critical window was similar to the daily declines in overall MVPA (approximately 50%).**
- **For older children, the decline in MVPA during the critical window was less than the overall decline in daily MVPA, suggesting that the critical window may be particularly important for physical activity in adolescents.**

What were the overall physical activity levels of children and adolescents on weekdays?

Figure 1 shows the amount of time (minutes) engaged in MVPA across the entire day on weekdays, for younger and older age groups and for boys and girls within these age groups, over the five-year study period.

Boys were more active than girls at each age group and at each time point during the study. Younger children were approximately twice as active as older children at each of the time points. For example, the mean daily MVPA for younger boys in 2001 was 277 mins/day compared to 150 mins/day for older boys.

Figure 1 Mean minutes per day spent in MVPA (total) on weekdays



The total time engaged in MVPA reduced as children got older, with a reduction of over 50% across all age groups over the five years. The reduction in MVPA over time was particularly marked in the older age group, with a reduction of almost two thirds seen over the five-year period.

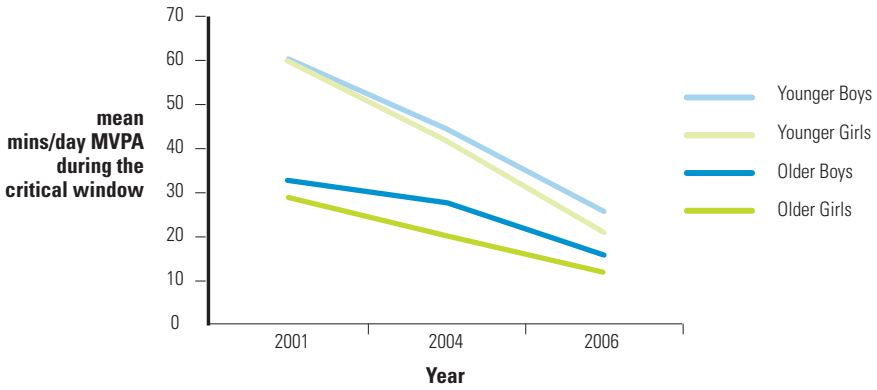
What were the levels of activity during the critical window?

Figure 2 shows the amount of time engaged in MVPA during the critical window for these groups over the same time periods. Consistent with the overall daily activity levels, the younger age group spent almost twice as much time in MVPA during the critical window compared with the older age group at each time point over the five years. Older boys performed significantly more MVPA during the critical window than older girls at each time point, which is also consistent with the overall patterns of daily activity described above. Levels of MVPA during the critical window were similar for younger boys and girls.

Corresponding to overall declines in physical activity (Figure 1), the amount of time engaged in MVPA during the critical window declined significantly over five years for both the younger and older age groups (Figure 2). In 2001, the younger boys and girls spent on average 61 minutes in MVPA during the critical window. By 2006, this had reduced to 26 minutes for the younger boys and 21 minutes for the younger girls (Figure 2).

Similar declines were seen for the older age group, with the older boys and girls performing on average 33 and 29 minutes of MVPA respectively during the critical window in 2001, declining to 16 minutes for the boys and 12 minutes for the girls in 2006. Significantly, the decline of time spent in MVPA during the critical window for the older age group (approximately 50%) was less than the decline seen in overall daily MVPA for this age group. This seems to indicate that the critical window may be particularly important for children in older age groups.

Figure 2 Mean minutes per day spent in MVPA during the critical window

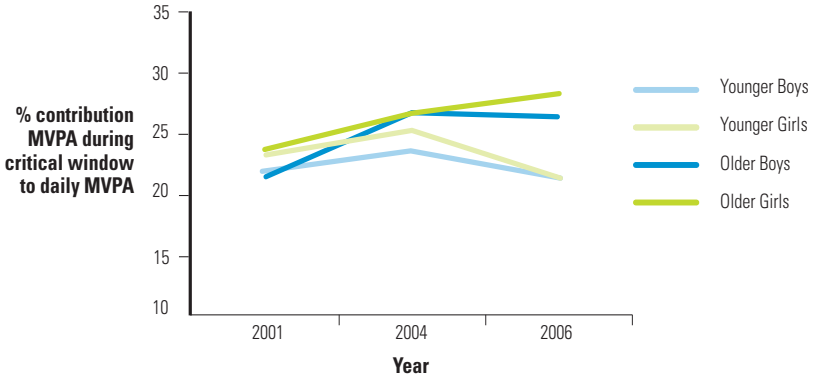


What proportion of physical activity occurred during the critical window?
Figure 3 shows the mean time spent in MVPA during the critical window as a percentage of time spent in MVPA across the entire day.

For the younger boys in 2001, the mean time spent in MVPA during the critical window contributed to 22% of their total daily time spent in MVPA. For the younger age group, there was little variation in the contribution of the critical window to total daily MVPA across the five-year period, ranging from 22% for boys and 23% for girls in 2001 to 21% for both boys and girls in 2006.

A greater variation in the contribution was observed for the older age group, ranging from 22% for boys and 24% for girls in 2001 to 27% for boys and 29% for girls in 2006. The overall percentage contribution of the critical window was higher for the older age group than the younger age group, further suggesting that the critical window may be more important for adolescent physical activity than for younger children. It is possible that adolescents are participating in more organised sport during this time than the younger children.

Figure 3 Time spent in MVPA during the critical window as a proportion (%) of total daily time spent in MVPA

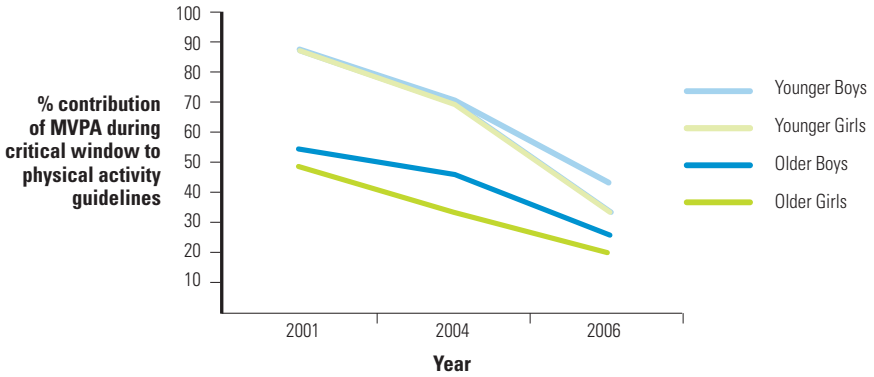


How did activity performed during the critical window contribute to children and adolescents meeting the guidelines for physical activity?
The importance of the critical window to children's and adolescents' physical activity can also be expressed in terms of its contribution to meeting the physical activity guidelines (60 mins/day MVPA) [5].

Figure 4 shows the mean time spent in MVPA during the critical window as a percentage of the minimum requirement of 60 minutes MVPA per day. For example, for the younger boys and girls in 2001, the mean time spent in MVPA during the critical window was equivalent to 87% of the total time needed to be spent in MVPA per day to meet the physical activity guidelines. By 2006, this had decreased to 44% for the younger boys and 34% for the younger girls.

For the older age group, in 2001 the mean time spent in MVPA during the critical window was equivalent to 54% of the total time needed to be spent in MVPA per day to meet the physical activity guidelines for boys and 48% for girls. Similar to the results for the younger age group, by 2006 this had decreased by more than 50% to 26% for boys and 20% for girls.

Figure 4 Time spent in MVPA during the critical window as a proportion (%) of the physical activity guidelines



3.3 The influence of the family environment on MVPA during the critical window

Key findings:

- **Parents of younger children were more likely to co-participate in physical activity with their children, whilst mothers of older youth were more likely to provide direct support such as providing transport, paying for participation etc.**
- **Younger and older boys with active mothers were more physically active during the critical window than boys with less active mothers.**
- **Younger and older boys with fathers who praised them for participating in physical activity tended to be more active during the critical window than boys with fathers who gave less praise.**
- **Older and younger girls with mothers who actively participated in physical activity with them tended to be more active during the critical window than girls with mothers who participated less often in physical activity with them.**

The study data were analysed to determine the association between the family environment features and the level of MVPA performed during the critical window.

Table 3 summarises the family environment features reported by parents of the participating children in 2001.

In terms of differences between older and younger children, there were few significant differences in family environment features reported by parents.

Co-participation in physical activity (i.e. how often family members actively participate in physical activity with the child) was more frequent among younger than older youth. In contrast, direct support for physical activity (i.e. parents taking the child to training, providing money for participation, buying sports clothing/equipment) was provided more frequently by mothers of older than younger youth.

Table 3: Role modelling, family participation, direct support & reinforcement variables reported by parents at baseline, by age of child

Predictor variables	Parents/sibling of younger children (n=190)[a]		Parents/sibling of older children (n=350)[a]	
Role modelling				
Father/male carer meets physical activity guidelines, % (n)	36.3	(69)	41.3	(142)
Mother/female carer meets physical activity guidelines, % (n)	56.9	(107)	58.2	(202)
Physical activity level of sibling (times/wk), M (SD)	3.4	(2.6)	4.0	(2.4)
Family particiption				
Father co-participates (times/wk) M (SD)	1.4	(1.4)	1.1	(1.2)*
Mother co-participates (times/wk) M (SD)	1.9	(1.7)	1.3	(1.3)*
Sibling co-participates (times/wk) M (SD)	3.1	(2.5)	2.5	(2.3)*
Family-based activities (times/wk), M (SD)	4.9	(4.2)	4.0	(4.0)
Direct support				
Father/male carer (times/wk) M (SD)	1.4	(1.6)	1.6	(1.7)
Mother/female carer (times/wk) M (SD)	2.0	(1.8)	2.7	(2.1)*
Reinforcement				
Father/male carer (times/wk) M (SD)	3.2	(2.6)	2.9	(2.4)
Mother/female carer (times/wk) M (SD)	4.0	(2.5)	3.6	(2.3)

**p<0.01, difference by age group; PA: physical activity; n: number of participants; M: mean; SD: standard deviation*
[a]Data restricted to those participants with accelerometry from at least 2 time points.

What factors are important for boys?

For both younger and older boys, associations were found between their average MVPA during the critical window over the five years and maternal role modelling (i.e. mothers' participation in physical activity) as well as with paternal reinforcement of physical activity (i.e. fathers' praise for participating in physical activity).

Younger (b: 3.6, 95% CI: -0.5, 7.8) and older (b: 2.8, 95% CI: -0.3, 6.0) boys whose mothers met the physical activity guidelines, participated in significantly more MVPA on average over five years during the critical window than boys whose mothers did not meet the physical activity guidelines.

Younger (b: 0.8, 95% CI: -0.1, 1.8) and older (b: 0.4, 95% CI: -0.1, 0.9) boys whose fathers provided positive reinforcement for their participation in physical activity, participated in significantly more MVPA on average over five years during the critical window than boys whose fathers did not provide such positive reinforcement.

What factors are important for girls?

Among girls, their mothers' or female carers' co-participation in physical activity was associated with the average amount of MVPA performed during the critical window. Girls (b: 0.6, 95% CI: -0.1, 1.2) whose mothers actively participated in physical activity with them, participated in significantly more MVPA on average over the five years during the critical window than girls whose mothers did not actively participate in physical activity with them.

Study conclusions

This study was one of the first internationally to examine physical activity during the critical window, and to examine the longitudinal relationships between the family environment and physical activity during the critical window among children and adolescents.

The importance of the critical window

The study findings affirm the importance of the critical window as an opportunity for children and youth to be active, with the mean time spent in MVPA during the critical window accounting for 21%-29% of total daily time spent in MVPA across all age groups and sexes for the five years. This contribution to total daily physical activity is less than reported in other studies that have used pedometers to measure physical activity among primary school aged students. These have shown that approximately 50% of the daily steps are taken during the after-school[7], or out-of-school period[10]. The after-school period in those studies, however, was defined from the end of school until bedtime and therefore extended beyond 6pm (the cut-off time in the current study), which most likely accounts for the higher figures reported.

Whilst younger children were more active overall than older children, the proportion of older children's physical activity performed in the critical window was higher than that for younger children in this study. This suggests that the critical window may be more important for adolescent physical activity than for younger children. It is possible that adolescents are participating in more organised sport during this time than the younger children.

Overall, the amount of time spent in MVPA during the critical window declined significantly over five years for both the younger and older age groups. These declines are consistent with previous research examining overall physical activity patterns[17,18] and highlight the need for strategies

to encourage and assist children and youth to continue participation in physical activity as they get older.

Significantly, the decline in time spent in MVPA during the critical window for the older age group (approximately 50%) was less than the decline seen in overall daily MVPA for this age group. This seems to further support the conclusion that the critical window is particularly important for children in older age groups.

Family environment factors that influence physical activity during the critical window

In terms of family environment factors that influence participation in physical activity, a limited number of studies have examined the relationship between parental or sibling participation in activities with children, and these have had mixed results. Some studies have observed positive correlations between frequency of parental co-participation in physical activity[22,25], but other studies have found no evidence of an association[22,25,26]. Furthermore, no previous research has examined co-participation using a longitudinal study design, employing objective measures of physical activity, or assessing physical activity during the critical time period after school until early evening.

In the current study, maternal (but not paternal) co-participation in physical activity was directly associated with MVPA during the critical window among girls, but not among boys. This finding suggests that for girls, having a family member to participate in physical activity with, rather than just observing or receiving support or praise from other family members, may be important for promoting physical activity.

The study also highlights the importance of parental role modeling of physical activity for boys, as boys with active mothers tended to be more physically active during the critical window. This suggests that targeting the physical activity of other family members may have important benefits for both youth and adult health. This finding is consistent with results from a cross-sectional Finnish study, where mothers' but not fathers' self-reported physical activity was correlated with boys' self-reported physical activity[19]. However, there appears to be no consistent pattern in the literature regarding parent-child physical activity associations according to the sex of the parent and child[20-24]. Importantly, none of these previous studies were longitudinal in design and only one used an objective measure of children's physical activity[20]. Furthermore, previous studies have focused on overall physical activity, while the current study assessed physical activity during a specific time period (critical window), when the family environment may be expected to have the most influence on children's and youths' physical activity.

The current study highlights the important role of fathers in terms of providing positive reinforcement of children's physical activity. This has not been previously identified in the literature.

Overall the study findings support approaches to physical activity promotion that target the critical window period as this is when a large proportion of children's MVPA is achieved.

Specific strategies should focus on encouraging parents to participate in physical activity with their child as well as praising and encouraging their child to participate in physical activity.

References

1. Andersen, L., Harro, M., Sardinha, L., Froberg, K., Ekelund, U., Brage, S., Anderssen, S. Physical activity and clustered cardiovascular risk in children: a cross-sectional study (the European Youth Heart Study). The Lancet. 2006;368:299-304.
2. Davison, K., Birch, L. Childhood overweight: a contextual model and recommendations for future research. Obesity Reviews. 2001; 2:159-71.
3. Wang, L., Lobstein, T. Worldwide trends in childhood overweight and obesity. International Journal of Pediatric Obesity. 2006; 1:1-64.
4. Trost, S. Discussion paper for the development of recommendations for children's and youth's participation in health promoting physical activity. Australian Government Department of Health and Ageing, 2003.
5. Australian Government Department of Health and Ageing. Australia's physical activity recommendations for 5-12 year olds. 2004. <http://www.healthyactive.gov.au>
6. Nader, P.R., Bradley, R.H., Houts, R.M., McRitchie, S.L., O'Brien, M. Moderate-to-vigorous physical activity from ages 9 to 15 years. The Journal of the American Medical Association. 2008; 300(3): 295-305.
7. Tudor-Locke, C., Lee, S., Morgan, C., Beighle, A., Pangrazi, R. Children's pedometer-determined physical activity during the segmented school day. Medicine and Science in Sports and Exercise. 2006; 38(10):1732-38.
8. Mota, J., Santos, P., Guerra, S., Ribeiro, J., Duarte, J. Patterns of daily physical activity during school days in children and adolescents. American Journal of Human Biology. 2003;15:547-53.
9. Welk, G.J, Corbin, C.B., Dale, D. Measurement issues in the assessment of physical activity in children. Research Quarterly for Exercise and Sport. 2000; 71(2):S59-73.
10. Cox, M., Schofield, G., Greasley, N., Kolt, G.S. Pedometer steps in primary school-aged children: A comparison of school-based and out-of-school activity. Journal of Science and Medicine in Sport. 2006;9:91-97.
11. Prochaska, J.J., Sallis, J.F., Griffith, B., Douglas, J. Physical activity levels of Barbadian youth and comparison to a U.S. sample. International Journal of Behavioral Medicine. 2002;9(4):360-72.
12. Hesketh, K., Graham, M., Waters, E. Children's after-school activity: associations with weight status and family circumstance. Pediatric Exercise Science. 2008;20:84-94.
13. Gustafson, S.L., Rhodes, R.E. Parental correlates of physical activity in children and early adolescents. Sports Medicine. 2006;36:79-97.
14. Van Der Horst, K., Paw, M.J., Twisk, J.W., Van Mechelen, W. A brief review on correlates of physical activity and sedentariness in youth. Medicine and Science in Sports and Exercise. 2007;39:1241-50.

15. Pate, R.R., Pratt, M., Blair, S.N., Haskell, W.L., Macera, C.A., Bouchard, C, et al. (1995) Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. The Journal of the American Medical Association. 1995;273:402-7.
16. Australian Department of Health and Aged Care. National physical activity guidelines for Australians. 1999. Canberra: Department of Health and Aged Care.
17. Sallis, J.F. Age-related decline in physical activity: a synthesis of human and animal studies. Medicine and Science in Sports and Exercise. 1999;32: 1598-600.
18. Nader, P.R., O'Brien, M., Houts, R., Bradley, R., Belsky, J., Crosnoe, R., Friedman, S., Mei, Z., Susman, E.J. Identifying risk for obesity in early childhood. Pediatrics. 2006;118: e594-601.
19. Fogelholm, M,. Nuutinen, O., Pasanen, M., Myohanen, E., Saatela, T. Parent-child relationship of physical activity patterns and obesity. International Journal of Obesity. 1999;23(12):1262-8.
20. Moore, L.L., Lombardi, D.A., White, M.J., Campbell, J.L. Oliveria, S.A., Ellison, R.C. Influence of parents' physical activity levels on activity levels of young children. Journal of Pediatrics.1991;118(2):215-9.
21. Anderssen, N., Wold, B. Parental and peer influences on leisure-time physical activity in young adolescents. Research Quarterly for Exercise and Sport. 1992; 63(4):341-8.
22. Sallis, J.F., Alcarez, J.E., McKenzie, T.L., Hovell, M.F., Kolody, B., Nader, P.R. Parental behavior in relation to physical activity and fitness in 9-year-old children. American Journal of Diseases of Children. 1992;146:1383-88
23. McMurray, R.G., Bradley, C.B., Harrell, J.S., Bernthal, P.R., Frauman, A.C., Shrikant, I., Bangdiwala, S.I. Parental influences on childhood fitness and activity patterns. Research Quarterly for Exercise and Sport. 1993;64(3): 249-55.
24. Cleland, V., Venn, A., Fryer, J., Dwyer, T., Blizzard, C.L. Parental exercise is associated with Australian children's extracurricular sports participation and cardiorespiratory fitness: a cross-sectional study. International Journal of Behavioral Nutrition and Physical Activity. 2005;2(1):3.
25. Sallis, J.F., Alcaraz, J.E., McKenzie, T.L., Hovell, M.F. Predictors of change in children's physical activity over 20 months. Variations by gender and level of adiposity. American Journal of Preventive Medicine. 1999;16(3):222-9.
26. Stucky-Ropp, R.C., DiLorenzo, T.M. Determinants of exercise in children. Preventive Medicine. 1993;22(6):880-9.

Children's and adolescents' physical activity during the critical window

Summary report