

Comparing levels of physical activity in children with and without type 1 diabetes

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Article points

1. In this study, children with type 1 diabetes were found to exercise less than their peers without diabetes.
2. Girls with diabetes exercised less than those without the condition, whereas the difference in boys was not significant.
3. Children with diabetes were less likely to exercise after school, while there was no difference between the groups during school hours.
3. Interventions should focus on girls with type 1 diabetes and on after-school activity.

Key words

- Exercise
- Paediatrics
- Type 1 diabetes mellitus

Authors

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Physical activity has known health benefits in children and young people, and those with type 1 diabetes may benefit additionally from improved glycaemic control. However, there is anxiety over the perceived negative effects of exercise, especially hypoglycaemia. This study compared levels of physical activity in children with and without type 1 diabetes. Participants were asked to fill in a validated physical activity questionnaire adapted for use in the UK. Children with diabetes, in particular girls, were found to be less active than those without the condition. These findings and their implications are discussed in this article.

Physical inactivity has been described as the biggest public health problem of the 21st century, with obesity rates among 10-year-olds in the UK rising from 1.7% in 1974 to 19.1% in 2015 (Blair, 2009). Today, approximately a third of children are either overweight or obese (Stamatakis et al, 2005; Health and Social Care Information Centre, 2015). Despite the benefits of exercise, children's physical activity (PA) often fails to meet recommended levels (Bélanger et al, 2011).

In response to this pandemic, the World Health Organization (2011) has made global recommendations for activity levels in children, and these have been adopted by the UK Government (Department of Health, 2011). These include moderate to vigorous PA for at least 60 minutes, and up to several hours, every day in all children.

In children with chronic health conditions, there is anxiety over perceived negative effects of exercise that, coupled with low expectations, often result in further restriction of activity (Riner and Sellhorst, 2013; Dantas et al, 2014; Santos-Silva et al, 2014). In type 1 diabetes, this negative perception, especially the fear of hypoglycaemia, exists and may be a contributory factor to low participation

rates and a higher prevalence of obesity (Kowalski et al, 2004; Wolfsdorf, 2005). Studies have shown that children with type 1 diabetes derive the same benefits from exercise as any other child, and in addition demonstrate improved glycaemic control (Massin et al, 2005; Quirk et al, 2014; Zebrowska et al, 2014). With individualised participation plans under qualified supervision, exercise should be a safe and rewarding experience (Wolfsdorf, 2005).

Despite being encouraged by the NICE (2015) guideline, PA levels in children with type 1 diabetes have not, to the authors' knowledge, been assessed previously, and PA promotion does not form a significant part of regular health screening in diabetes clinics. Therefore, in this study, we aimed to compare levels of PA in children with and without type 1 diabetes. Our secondary aim was to compare BMI in the two groups.

Methods

Participants

Children between the ages of 7 and 17 years were eligible to participate. Children with type 1 diabetes were recruited from May to August 2016

from a paediatric diabetes clinic in a London teaching hospital. Clinics were attended by an investigator, who distributed patient information leaflets to children and their parents or carers detailing the study. The patient information leaflets were age-appropriate in their content.

If participation was agreed, written consent was obtained and a PA questionnaire was provided for completion by the children while waiting for their clinic. The investigator remained available to provide assistance upon request.

The control group of children without diabetes was recruited from one primary and one secondary school in Monmouthshire. The same consent was obtained.

The children with type 1 diabetes recruited to the study attended different schools over a wide area, making a truly representative control group impossible to obtain. Due to the disparate nature of the study group, the main criteria for the selection of the control group was not proximity to the clinic but an interest in child healthcare research ideals and the willingness of children, parents and administrative staff to engage with researchers.

Ethical approval

This study was conducted with the approval of the NHS Health Research Authority (16/LO/0723), as well as the local research and development committee, which gave protocol ratification. Informed consent was obtained from the parents or legal guardians of participants under 16, with the option for participants to also give their consent. Two participants, aged 16 and 17, gave their consent independently.

Physical activity questionnaire

We used the Physical Activity Questionnaire (PAQ), a self-report questionnaire developed by Kowalski et al (2004) to measure PA in children. The PAQ comprises nine validated questions relating to PA undertaken in the previous week and is designed for school-age children and young people. Each question is scored out of five and a final score is calculated as the mean of all nine responses; higher scores indicate higher activity.

The original questions were validated for a Canadian population and so minor revisions were

made in terms of sporting activities and phrasing to adjust for cultural and sporting preferences in the UK. In particular, question 1 lists 22 sports that respondents are asked to quantify involvement in over the preceding week; in place of floor hockey, street hockey, ice hockey, ice skating, baseball and Canadian football, we inserted tennis, athletics, cricket, rugby, martial arts and gymnastics. Previous studies conducted in the UK and other countries have shown that the revision of questions to suit the local population provides satisfactory results and validity (Janz et al, 2008; Bervoets et al, 2014; Thomas and Upton, 2014; Aggio et al, 2016).

Questions 2–8 relate to activity at specific times of the day and question 9 asks how often PA was performed for each day of the preceding week. The same revised questionnaire was used for all participants, with slight graphic design differences between the 7–11 and 11–17 age groups. The two versions of the revised PAQ are in *Appendix 1*, available with the online version of this article.

Analysis

Basic demographics, final PAQ activity scores and the types of sports practised were calculated and analysed. To determine the statistical significance between the PAQ responses of the two groups, a two-sample *t*-test was used. This statistical analysis was also carried out for the comparison of various subgroups (boys, girls, younger children, adolescents, and PA during and after school hours).

We also measured height and weight for both groups to calculate BMI. *t*-tests were conducted to investigate the potential differences between the BMI results of children with and without type 1 diabetes.

Results

A total of 31 children with type 1 diabetes and 65 without the condition were entered into the study. The population characteristics for the two groups are presented in *Table 1*. Overall, the group with diabetes was less active than the group without the condition, with an average PAQ score of 2.74 compared with 3.08 ($P=0.038$).

As can be seen in *Table 2*, girls with diabetes were less active than those without the condition (PAQ scores 2.33 vs 2.91; $P=0.003$). There was no

Take-home points

- Department of Health recommendations for exercise apply to children with type 1 diabetes.
- There is concern in the general population about children with type 1 diabetes “overdoing” exercise.
- Health promotion does not form a significant part of routine diabetes outpatient assessment.
- Children and young people with type 1 diabetes exercise significantly less than those without the condition, potentially denying them the many health benefits of exercise.
- Compared to those without the condition, children with type 1 diabetes exercise less after school, while levels are similar during school hours, implying a negative home influence.
- Girls with type 1 diabetes have significantly lower exercise levels than those without the condition and should be a focus for exercise promotion in line with national initiatives.

Table 1. Characteristics of the study participants.

Age (years)	Children with diabetes			Children without diabetes		
	Girls	Boys	Total	Girls	Boys	Total
7–9	1	7	8	10	10	20
10–11	3	5	8	12	9	21
12–13	3	4	7	7	5	12
14–15	5	1	6	7	5	12
16–17	0	2	2	0	0	0
Total	12	19	31	36	29	65

difference between the groups when comparing the PA of boys ($P=0.197$), children ($P=0.075$) or adolescents ($P=0.400$).

We analysed the data to compare activity levels during and after school. No significant difference was found between the groups for PAQ questions 2, 3 and 4, which relate to school-time activity (PAQ scores 3.39 vs 3.58 in the diabetes group vs the non-diabetes group, respectively; $P=0.370$). There was, however, a significant difference in activity after school in those with diabetes compared to those without the condition, as measured by PAQ questions 5, 6, and 7 (mean score 2.54 vs 3.02; $P=0.02$).

All activities and sports practised in the week leading up to PAQ completion are listed in Table 3. Overall, the five most popular sports were lacrosse (practised by 97% of the total cohort), badminton (93%), volleyball (90%), rollerblading (90%) and hockey (87%). In the group of children with diabetes, hockey, netball and martial arts were the joint fifth most popular sports, whereas in children without diabetes, volleyball and netball came joint fifth.

We aimed to compare BMIs for all participants; however, this was not possible for the primary school-age children in the control group as the necessary equipment was unavailable. We therefore restricted the BMI comparison to children aged 11–17 years. In this age group, there was no significant difference in BMI between the groups ($P=0.903$; Table 4). There were no significant differences in the BMIs of girls ($P=0.562$) or boys ($P=0.420$) with and without diabetes.

Discussion

The benefits of exercise include cardiovascular health, muscle and bone strengthening, psychological and social wellbeing, skill attainment and weight control (Janssen and Leblanc, 2010; Okely et al, 2012). Children with chronic conditions stand to gain as much, if not more, from exercise as otherwise healthy subjects (Wolfsdorf, 2005; Riner and Sellhorst, 2013); however, they face barriers that arise from a fear of “overdoing it” and a misunderstanding of what exercise entails (Thornton, 1997).

In an era where activity rates are deemed generally low, England is ranked joint 34th out of 38 countries according to The Global Matrix 2.0 on Physical Activity for Children and Youth (Tremblay et al, 2016). Intuitively, in light of such poor levels of PA in the general population, expectations in children with chronic illness would be low (Wilkie et al, 2016).

Our results indicate that children with type 1 diabetes are significantly less active than those without diabetes, despite the benefits of exercise described, plus the added advantage of increased insulin sensitivity and reduced HbA_{1c} (Health and Social Care Information Centre, 2015; Massin et al, 2005).

Arguably, there is more PA-related anxiety associated with type 1 diabetes than with other chronic conditions because of the fear of hypoglycaemic events. This fear plays a significant role in the mindset of carers and may contribute to lower PA rates (Brazeau et al, 2008).

Although there was no significant difference between the two groups during school time, PA was found to be significantly lower in the diabetes group after school. School PA includes programmed play, and these results suggest that parents are allowing children with type 1 diabetes to participate in games classes. These children are also active in spontaneous PA during school time, which suggests that they want PA in their daily routine. After school, however, something changes and PA levels become significantly lower in children with diabetes. For most children, especially in the early years, parents have a strong influence on extracurricular activity, and it must be considered that discouragement originating from parents, whether voiced or otherwise, may

be a factor in the low out-of-school PA levels in children with diabetes.

BMI was not significantly different between the groups, which is not surprising as the PAQ, while providing good consistency, does not assess duration or intensity of activity and cannot reliably inform on fitness levels (Janz et al, 2008). This does not reduce the relevance of the PAQ, as recent studies have indicated that activity is a more important single variable than obesity in overall health (Ekelund et al, 2015).

Concerns over exercise-induced hypoglycaemia remain controversial. Hypoglycaemia accounts for up to 4–10% of deaths in people with type 1 diabetes (Sequist et al, 2013), although there are no published cases of deaths occurring during PA due to hypoglycaemia. Overall, the risk for children with type 1 diabetes undertaking PA is deemed to be small (Burr, 2012). Accordingly, NICE (2015) and the American Diabetes Association (2013) support exercise in children, although it would be unwise to ignore the phenomenon of hypoglycaemia completely. During exercise, the sequence of body processes leading to glucose supply and removal from the bloodstream is intricate and will never be precisely mirrored with exogenous insulin regimens or novel delivery systems. In addition, the “after burn” effect of higher-than-normal energy consumption following moderate- to high-intensity PA can be sustained for 24 hours and potentially cause episodes of delayed hypoglycaemia.

In order to remain safe, PA in children with type 1 diabetes needs careful planning with provision of individually tailored advice on nutrition and insulin requirements. This would ideally be supplied at routine diabetes clinic reviews, aided by a physician with an interest in sports and exercise medicine. Support and literature detailing local sports clubs and activity groups should also be made available, with locally provided sports introduction classes offered to break down apprehension and misconceptions about PA.

Our study found that girls with type 1 diabetes exercised significantly less than those without the condition, whereas there was no significant difference between groups in boys. It is widely known, both in the UK and worldwide, that boys engage in PA more than girls at almost every

Table 2. Physical Activity Questionnaire scores.

Score	Children with diabetes (n=31)	Children without diabetes (n=65)	P-value
Overall			0.038*
<i>n</i>	31	65	
Mean (standard deviation)	2.74 (0.75)	3.08 (0.66)	
Range	0.89–4.01	1.58–4.44	
Children (7–11 years)			0.075
<i>n</i>	16	41	
Mean (standard deviation)	3.01 (0.55)	3.31 (0.58)	
Range	1.96–3.83	2.31–4.44	
Adolescents (12–17 years)			0.400
<i>n</i>	25	24	
Mean (standard deviation)	2.46 (0.84)	2.68 (0.61)	
Range	0.89–4.01	1.58–3.66	
Girls			0.003*
<i>n</i>	12	36	
Mean (standard deviation)	2.33 (0.50)	2.91 (0.67)	
Range	1.58–3.17	1.58–4.23	
Boys			0.197
<i>n</i>	19	29	
Mean (standard deviation)	3.01 (0.77)	3.28 (0.61)	
Range	0.89–4.01	2.22–4.44	
Overall school-time activity (questions 2, 3, 4)	3.58	3.39	0.370
Overall after-school activity (questions 5, 6, 7)	2.53	3.24	0.0014*

*Significant difference.

age range (Sherar et al, 2007). As a result, sports participation initiatives for girls have been set up in many countries. “This Girl Can” is an example of one such initiative in the UK. However, it is not clear why girls with type 1 diabetes have fallen behind boys when it comes to exercising as much as their peers without the condition. Whether girls with diabetes are regarded as particularly

Table 3. Activities children had undertaken in the previous week, in order of total popularity.

Activity	Children with diabetes, n=31 (%)	Children without diabetes, n=65 (%)	Total, n=96 (%)
Lacrosse	30 (97)	63 (96)	93 (97)
Badminton	30 (97)	58 (89)	88 (93)
Rollerblading	30 (97)	54 (83)	84 (90)
Volleyball	30 (97)	54 (83)	84 (90)
Hockey	28 (90)	55 (84)	83 (87)
Netball	28 (90)	54 (83)	82 (86)
Skateboarding	27 (87)	51 (78)	78 (83)
Martial arts	28 (90)	49 (75)	77 (83)
Gymnastics	23 (74)	49 (75)	72 (75)
Skiping	22 (71)	44 (67)	66 (69)
Basketball	23 (74)	41 (63)	64 (69)
Rugby	27 (87)	37 (57)	64 (67)
Cricket	22 (71)	43 (66)	63 (67)
Tennis	21 (68)	42 (65)	63 (67)
Dance	19 (61)	38 (58)	57 (60)
Cycling	21 (68)	33 (50)	54 (59)
Athletics	14 (45)	38 (58)	52 (52)
Swimming	16 (51)	34 (52)	50 (52)
Walking	5 (16)	17 (26)	42 (21)
Tag	15 (48)	21 (32)	36 (40)
Football	11 (35)	18 (27)	29 (31)
Jogging/running	7 (23)	13 (20)	20 (22)

vulnerable to the perceived ill effects of exercise or whether traditional biological, psychological, social and environmental factors play a significant role needs to be clarified (Sallis, 1995; Telford et al, 2016). We were unable to demonstrate a significant difference in PA between children with type 1 diabetes and controls in the 7–11 and 12–17-year age groups.

Study limitations

This study had a relatively small sample size

and further research is required, with more participants, to confirm these findings.

Self-reporting questionnaires are commonly used in sports and exercise medicine, and have been successful, in part, because of their simplicity. As with the PAQ, however, limitations exist. Children with higher PA levels may be more likely to volunteer to participate, and exaggeration may take place due to the natural tendency towards self-promotion. Despite this, the PAQ has demonstrated moderate validity and reliability, and has been extensively utilised in research (Kowalski et al, 2004).

Conclusions

Falling levels of activity in children are a global concern, and children with type 1 diabetes seem particularly susceptible to this trend. Active intervention to increase PA levels in children with diabetes, with a particular focus on girls and after-school activity, should be provided by a multidisciplinary team engaging the whole family. Further work should be extended to other groups of children with chronic illness to ensure that the many benefits of PA are experienced by all. ■

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Table 4. BMI scores (in kg/m²) for children aged ≥11 years.

BMI	Children with diabetes	Children without diabetes	P-value
All children			0.903
<i>n</i>	15	26	
Mean (standard deviation)	21.8 (4.3)	21.7 (3.5)	
Range	14.9–32.7	15.7–27.5	
Girls			0.424
<i>n</i>	6	16	
Mean (standard deviation)	23.6 (5.5)	21.0 (2.7)	
Range	17.1–32.7	15.7–27.3	
Boys			0.943
<i>n</i>	9	10	
Mean (standard deviation)	20.5 (3.6)	23.0 (2.41)	
Range	14.9–25.2	20.4–27.5	

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Physical Activity Questionnaire

Primary School (Age 8 - 11)

Hello! Thank-you for helping us ☺ Please start by filling in the blank spaces below.

My name is: _____

My age is: _____ years old

My height is: _____ metres

My weight is: _____ kg

School Year: _____

I am a: Boy

☐

Girl

☐


Well done! We are trying to find out about your level of physical activity over *the last 7 days* (in the last week). This includes sports or dancing that make you sweat or make your legs feel tired, or games that make you breathe hard – just like football, skipping, running and climbing! **Remember...** This is not a test (there are no right or wrong answers) so answer all the questions as honestly as you can – this is very important!

QUESTION 1: In your spare time over the past 7 days (last week), have you done any of the following activities? If yes, how many times? (Tick **ONE** box per row!)

	No	1-2	3-4	5-6	7 or more
Skipping					
Tag					
Walking for exercise					
Cycling					
Gymnastics					
Dance					
Swimming					
Skateboarding					
Rollerblading					
Jogging or running					
Football					
Rugby					
Lacrosse					
Tennis					
Cricket					
Athletics					
Badminton					
Volleyball					
Hockey					
Basketball					
Netball					
Martial Arts					
Other:					



QUESTION 2: In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing *etc.*)? (Tick one only)

- I don't do PE ☐
- Hardly ever ☐
- Sometimes ☐
- Quite often ☐
- Always ☐



QUESTION 3: In the last 7 days, what did you do most of the time at break time? (Tick one only)

- Sat down (talking, reading, doing schoolwork) ☐
- Stood around or walked around ☐
- Ran or played a little bit ☐
- Ran around and played quite a bit ☐
- Ran and played hard most of the time ☐



QUESTION 4: In the last 7 days, what did you normally do at lunch (besides eating lunch)? (Tick one only)

- Sat down (talking, reading, doing schoolwork) ☐
- Stood around or walked around ☐
- Ran or played a little bit ☐
- Ran around and played quite a bit ☐
- Ran and played hard most of the time ☐



QUESTION 5: In the last 7 days, on how many days right after school, did you do sports, dance, or play games in which you were very active? (Tick one only)

- None ☐
- 1 time last week ☐
- 2 or 3 times last week ☐
- 4 times last week ☐
- 5 times last week ☐



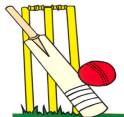
QUESTION 6: In the last 7 days, on how many *evenings* did you do sports, dance, or play games in which you were very active? (Tick one only)

- None ☐
- 1 time last week ☐
- 2 or 3 times last week ☐
- 4 or 5 times last week ☐
- 6 or 7 times last week ☐



QUESTION 7: *Last weekend*, how many times did you do sports, dance, or play games in which you were very active? (Tick one only)

- None ☐
- 1 time ☐
- 2 - 3 times ☐
- 4 - 5 times ☐
- 6 or more times ☐



QUESTION 8: Which *one* of the following describes you best for the last 7 days? Read *all five* statements before deciding on the answer that describes you. (Tick *one only*)

- 1. All or most of my free time was spent doing things that involve little physical effect ☐
- 2. I sometimes (1 – 2 times) did physical things in my free time (e.g. played sports, running, cycling)..... ☐
- 3. I often (3 – 4 times last week) did physical things in my free time ☐
- 4. I quite often (5 – 6 times last week) did physical things in my free time ☐
- 5. I very often (7 or more times last week) did physical things in my free time ☐



QUESTION 9: Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week. (Tick *ONE box per row*)

	None	Little bit	Medium	Often	Very often
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					



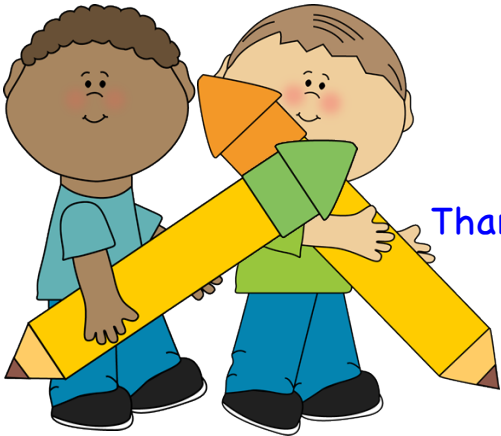
QUESTION 10: Were you sick last week, or did anything prevent you from doing your normal physical activities? (Tick *one only*)

Yes ☐

No ☐

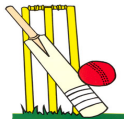
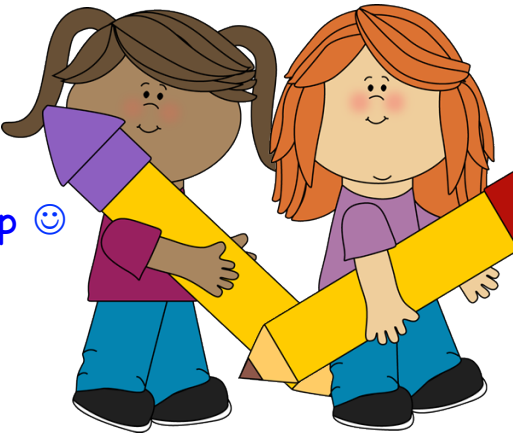


If 'yes', what prevented you:



THE END!

Thank-you for your help 😊



Physical Activity Questionnaire

Secondary School (12+)

Hello! Thank-you for helping us ☺ Please start by filling in the blank spaces below.



Name: _____ Age: _____ years old School Year: _____

Height: _____ m Weight: _____ kg Sex Male ☐ Female ☐

Well done! We are trying to find out about your level of physical activity over *the last 7 days* (in the last week). This includes sports or dancing that make you sweat or make your legs feel tired, or games that make you breathe hard – just like football, skipping, running and climbing! **Remember...** This is not a test (there are no right or wrong answers) so answer all the questions as honestly as you can – this is very important!

QUESTION 1: In your spare time over the past 7 days (last week), have you done any of the following activities? If yes, how many times? (Tick **ONE** box per row!)

	No	1-2	3-4	5-6	7 or more
Skipping					
Tag					
Walking for exercise					
Cycling					
Gymnastics					
Dance					
Swimming					
Skateboarding					
Rollerblading					
Jogging or running					
Football					
Rugby					
Lacrosse					
Tennis					
Cricket					
Athletics					
Badminton					
Volleyball					
Hockey					
Basketball					
Netball					
Martial Arts					
Other:					



QUESTION 2: In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing *etc.*)? (Tick one only)

- I don't do PE ☐
- Hardly ever ☐
- Sometimes ☐
- Quite often ☐
- Always ☐



QUESTION 3: In the last 7 days, what did you do most of the time at break time? (Tick one only)

- Sat down (talking, reading, doing schoolwork) ☐
- Stood around or walked around ☐
- Ran or played a little bit ☐
- Ran around and played quite a bit ☐
- Ran and played hard most of the time ☐



QUESTION 4: In the last 7 days, what did you normally do at lunch (besides eating lunch)? (Tick one only)

- Sat down (talking, reading, doing schoolwork) ☐
- Stood around or walked around ☐
- Ran or played a little bit ☐
- Ran around and played quite a bit ☐
- Ran and played hard most of the time ☐



QUESTION 5: In the last 7 days, on how many days right after school, did you do sports, dance, or play games in which you were very active? (Tick one only)

- None ☐
- 1 time last week ☐
- 2 or 3 times last week ☐
- 4 times last week ☐
- 5 times last week ☐



QUESTION 6: In the last 7 days, on how many *evenings* did you do sports, dance, or play games in which you were very active? (Tick one only)

- None ☐
- 1 time last week ☐
- 2 or 3 times last week ☐
- 4 or 5 times last week ☐
- 6 or 7 times last week ☐



QUESTION 7: *Last weekend*, how many times did you do sports, dance, or play games in which you were very active? (Tick one only)

- None ☐
- 1 time ☐
- 2 – 3 times ☐
- 4 – 5 times ☐
- 6 or more times ☐



QUESTION 8: Which *one* of the following describes you best for the last 7 days? Read *all five* statements before deciding on the answer that describes you. (Tick one only)

- 1. All or most of my free time was spent doing things that involve little physical effect ☐
- 2. I sometimes (1 – 2 times) did physical things in my free time (e.g. played sports, running, cycling)..... ☐
- 3. I often (3 – 4 times last week) did physical things in my free time ☐
- 4. I quite often (5 – 6 times last week) did physical things in my free time ☐
- 5. I very often (7 or more times last week) did physical things in my free time ☐



QUESTION 9: Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week. (Tick ONE box per row)

	None	Little bit	Medium	Often	Very often
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					



QUESTION 10: Were you sick last week, or did anything prevent you from doing your normal physical activities? (Tick one only)

Yes ☐

No ☐



If 'yes', what prevented you:



THE END!

Thank-you for your participation 😊

