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Working Paper No. 272

January 2009

The Games We Used to Play
An Application of Survival Analysis to the Sporting Life-course

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Subsequently published in "The Sports and Exercise Life-course: A Survival Analysis of Recall Data from Ireland " Social Science & Medicine, Vol. 70, Issue 5, pp.711-719.

Abstract: In the absence of longitudinal data, recall data is used to examine participation in sport. Techniques of survival analysis are adapted and applied to illuminate the dynamics of sporting life. The likelihood of participation has a distinct pattern across the life-course, rising to a peak at 15 years of age, falling sharply in late teenage years and more gradually during adulthood. Logistic regressions and Cox regressions reveal strong effects on participation of gender, cohort and socioeconomic status, which vary over the life-course and by type of sport. The findings add significantly to previous work and have implications for policymakers wishing to increase physical activity.

Keywords: Sporting participation; Health; Survival analysis; Recall data

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* This paper has been improved substantially following many comments and suggestions made in response to earlier drafts and presentations. In particular, I would like to thank Professor Tony Fahey, Professor Richard Layte, Dr Daniel Lunn, Dr Mary Lunn and Professor Brian Nolan for their contributions. I am also grateful to the Irish Sports Council for their support of ESRI research on participation in sport.

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1. Introduction

By employing recall data and applying survival methods, this paper adopts a novel approach to the analysis of participation in sport and physical exercise. Survey data from Ireland are used to reconstruct individual sporting histories. An adapted form of the Kaplan-Meier survival curve provides a depiction of involvement in sport across the life-course, which identifies key transition points. The method also allows cross-sectional and survival regression models to be constructed, which offer insight into the determinants of participation at different life-stages and the determinants of transitions into and out of participation. The method is limited by sampling issues and recall error, but with a sample of over 3,000 adults it produces useful results and notable policy implications.

Increased participation in sport is now seen as an important goal by governments worldwide. Modern public health policies have greatly increased the emphasis on physical activity, as mortality in developed nations has come to be determined more by degenerative than by infectious disease. The World Health Organisation lists physical activity as one of the seven leading risk factors associated with the development of serious disease (World Health Organisation Europe, 2005).

Recognition of the link between physical activity and health has inspired a considerable research effort, which aims to inform policymakers of the factors associated with participation in sport and exercise. Large-scale surveys of sporting participation have been carried out in many countries, with much analysis focused on the socioeconomic and sociodemographic determinants of participation. The standard statistical approach is cross-sectional regression. Across a range of countries, this method has been used to show that women, older people and those of lower socioeconomic status are less likely to participate in sport and exercise (Stamm and Lamprecht, 2005; Farrell and Shields, 2002; Stratton et al., 2005; Lunn, 2007). Other factors, including parental sporting involvement, health status, ethnicity, transport

access and marital status also emerge as significant in a proportion of such studies. A constant refrain, however, is that the lack of longitudinal data limits our understanding of the dynamics of people's sporting lives.

Those longitudinal studies that do exist tend to be based on non-representative and small samples, followed up one or more decades after completing a childhood survey on physical activity. An exception is the study of Telama et al. (2005), which employed a random sample of more than 1,500 Finnish children surveyed in 1980 and 2001. Scores on a physical activity index, based mostly on sporting activity, displayed a low to moderate correlation between the two dates (0.33 – 0.44 for males, 0.14 – 0.26 for females), which varied by age at the time of the initial survey.

This finding suggests that sporting habits formed when young influence participation in later life to some degree, but that transitions in sporting participation between childhood and adulthood are also important. The novel contribution of present paper is to use recall data and to apply some techniques of survival analysis to improve understanding of these transitions.

The structure of the paper is a follows. Section 2 describes the data and method, discussing the advantages and limitations that accompany the use of recall data in this context. Section 3 presents descriptive analyses. Section 4 provides logistic regression models of the likelihood of having participated in sport and exercise as a teenager and as a young adult. Section 5 reports survival models of the take-up of and drop-out from sport during adulthood. Section 6 concludes and discusses policy implications.

2. Sporting Histories Data

The Survey of Sport and Physical Exercise was carried out by the Survey Unit of the Economic and Social Research Institute (ESRI) in 2003. It collected detailed information about sporting activity from a random sample of adults aged 18 and over drawn from the electoral register in Ireland, plus a standard set of background characteristics. Interviews were conducted face-to-face at home. The response rate was 67%, giving a final sample of 3,080. The sample profile accords closely with the

Irish Census of 2002, although where participation rates are reported below, the sample is reweighted by age, gender and region to give conformity with the Census.

The definition of sport adopted in the survey is broad. Non-competitive personal exercise activities (e.g. swimming, going to the gym, running) are included in the definition of 'sport', along with hillwalking and competitive walking (i.e. athletics), but not recreational walking (i.e. going for a walk). Informal activity with friends and family is considered equivalent to organised activity with a sports club. Respondents were informed that this definition of sport was being used at the beginning of the survey and were shown a list of more than 60 activities that complied with the definition. They were asked whether they had participated in each of these sport and exercise activities during the previous twelve months and, if so, how often. An open question also permitted respondents to state that they played a sport not on the list. For each activity, information was gathered about the age at which the individual had taken up the sport. A subsequent section of the survey repeated this exercise for any sports that the respondent used to play "on a regular basis" but had given up. The term "regular" was not precisely defined, but previous sections had employed a definition of at least once a month. For these activities, the age at which the respondent stopped playing was also recorded.

The survey responses allow individual sporting histories to be constructed, recording for every year up to the respondent's age at the time of the survey whether the individual was playing regular sport and, if so, which specific sports. The advantage of this transformation of the data is to permit an analysis of participation across the life-course and of transitions into and out of participation. The obvious disadvantage is that there may be error, perhaps considerable error, in respondents' recollections. Specific data concerns include possible biases due to error in recall (including missing values), the potential for sample bias induced by population change, and the unavailability of explanatory variables relating to the past.

2.1 Recall failure

Complete sporting histories can be constructed for 2,896 (94.0%) of the sample. The remaining 6.0% responded "don't know" to at least one of the historical questions

relating to the age of take-up or drop-out from a sport. They are excluded from further analysis. This unavoidably introduces a modest downward bias in participation rates, since those unable to recall are more likely to have been among the individuals (78%) who had at some time in their lives participated in sport. Further analysis of the excluded group reveals that failure to recall is not significantly related to background characteristics, save that those under 30 years have a significantly lower rate of recall failure (3.8%). Hence, the degree of downward bias in participation differs between this group and the rest of the sample. Relative to the differences explored in the following sections this differential bias is small, however. Moreover, the regression models reported below are robust to the exclusion of those under 30 years – the coefficients do not change significantly.

2.2 Recall error

The obvious downside of employing recall data is the potential for measurement error and other possible biases introduced by inaccurate recollection. Recall data has previously been used to examine various research questions in economics and sociology, including factors influencing unemployment, educational attainment and health service usage. Dex (1991) extensively reviews earlier studies; Bound et al. (2001) provide a meta-analysis. The conclusions from both of these analyses are consistent: recall data is subject to less error when the recall period is shorter, when the activity being measured is salient, and when the behaviour is habitual and lasts for a long period. Given the latter two conclusions, sporting participation may be suitable for analysis using recall data, because periods of playing regular sport tend to extend over years and to involve salient events. On the downside, recall in the present case extends over several decades.

The evidence considered by Dex (1991) also suggests that face-to-face surveys and aided recall (lists of prompts) further improve the accuracy of data. The present survey was carried out face-to-face and respondents were heavily prompted. By the time they encountered the section asking about their sporting past, respondents had already been exposed to the full list of sports twice and were required to respond separately to each sport listed, stating whether they had ever played it regularly. The relevant section also asked about the context in which the activity took place (i.e.

formally with a club, informally with friends, etc.), whether instruction or tuition was received, respondents' perceptions of their own ability, whether they were on the school team and the reason for ceasing regular participation. These questions produced a lower incidence of "don't knows" than the questions relating to starting and stopping ages, suggesting that respondents found it easier to recall participating in activities than to provide ages of taking them up and dropping out.

Given this pattern, it seems unlikely that entire participation periods are missing, i.e. that some respondents stated that they had never regularly played a sport that, in fact, they had played. The greater concern is the accuracy of the ages of taking up and dropping out from specific activities, perhaps especially the latter, which accounts for a greater proportion of missing values. Moreover, a notable aspect of the data is that although the distribution of ages that respondents gave for when they started activities is fairly smooth, the ages supplied for ceasing activities beyond 30 years of age tend to clump around ages divisible by five. An issue, therefore, is whether these inaccuracies are approximations that merely introduce noise to the data, or whether they introduce systematic bias. For instance, it is possible that recollections are influenced by norms that dictate appropriate ages for playing sport, rather than by actual past behaviour. While this cannot be ascertained for sure, some relevant evidence is presented in Section 3. Preliminary analyses also indicated no association between the tendency to provide salient ages and the explanatory variables employed in the main analysis.

2.3 Sample consistency

Based on the individual histories, the peak age for sporting activity is 15 years old (see below). The mean age of survey respondents is 44. Hence, for the average respondent, the year of most likely participation in sport is 1974. Yet a representative cohort of the adult population in 2003 will be a biased sample of the equivalent cohort in 1974. Of any representative sample in 1974, some people will die and, especially in Ireland, migrate. In addition, the 2003 sample may contain immigrants who were living elsewhere in 1974. If death and migration are correlated with the likelihood of playing sport, biases could be introduced.

With the recall method, this problem is unavoidable, but it is possible to control for it to some degree. With respect to bias arising from survival, models can be checked for robustness when the sample is limited to those under a specific age, say 50 or 60 years old, when the bias should be greatly reduced. In fact, the appropriate control for migration turns out to be similar. Controlling for immigration is difficult, because immigrants were not identified in the survey, but large-scale immigration (as distinct from return emigration) to Ireland is a very recent phenomenon and the proportion of immigrants on the electoral register by 2003 would have been very low. The greater issue is emigration. Population outflows peaked in the 1950s and again in the 1980s, but the large majority of emigrants in the latter wave had returned by 2003 (Fahey, Fitz Gerald and Maître, 1998). Hence, if sample biases result from deaths and emigration, limiting the analysis to the under 50 age group provides a reasonable control. Again, the analysis to be presented is robust to limiting the sample in this way – the regression coefficients do not change significantly.

2.4 Background characteristics

One aim is to relate sporting histories to sociodemographic and socioeconomic background characteristics. The historical section of the survey was limited to sporting activity, so the available explanatory variables are recorded for the year 2003. Some variables, such as gender and date of birth can be considered fixed, but socioeconomic status is not so consistent across the life-course. The analysis makes use of the maximum level of educational attainment, yet some respondents might attain this level quite late in adult life. The other main socioeconomic indicators available, household income and social class, could differ markedly between 2003 and previous years, although each tends to be highly correlated over time and between subsequent generations of the same family. Given the available indicators for income and class, this problem is unavoidable and the variables as measured in 2003 are effectively proxies for their previous values. This measurement error is likely to lessen the estimated associations between these variables and participation in sport, unless there is significant reverse causality, i.e. unless participation in sport has a significant influence on future socioeconomic status.

2.5 Summary of data concerns

On the upside, the use of aided recall and the low prevalence of missing values offers reassurance that entire sporting episodes are unlikely to missing from the data. Meanwhile, limiting the sample to particular age ranges permits tests for sample biases introduced by differential recall failure and by changes in sample composition over time. These tests suggest the results are not significantly affected by such biases. On the downside, the use of recall data is likely to introduce significant measurement error in respect of starting and stopping ages for playing sports. Furthermore, using variables relating to socioeconomic circumstances in 2003 as proxies for their previous values implies measurement error in key explanatory variables also. The likely effect of both these sources of error on the estimated strengths of the associations reported below is to reduce them, meaning that significant findings are likely to be more solid with respect to the direction of the effect they reveal than with respect to its estimated magnitude. These limitations of the method need to be borne in mind.

3. Graphical Analysis of the Sporting Life-course

The recall data provide information regarding whether all individuals were playing regular sport during every year up to 18 years of age. Beyond this, the sample begins to be reduced, as a proportion of individuals are yet to reach the age in question. That is, as age increases there is a steady increase in the number of censored observations. To deal with this censoring, techniques of survival analysis can be adapted.

3.1 The Sport Hill

Figure 1 provides a depiction of participation in sport across the life-course, which is henceforth referred to as the "sport hill". It is, in effect, an adapted form of Kaplan-Meier analysis (Kaplan and Meier, 1958). The section of the hill beyond 18 years resembles the Kaplan-Meier estimator of the survivorship function in that, as age increases, the proportion playing regularly is calculated only from the remaining "risk set", i.e. those who have reached the age in question. Hence, the similarity between

the sport hill and Kaplan-Meier analysis is the method used for handling right censored observations. The difference is that individuals can change status in either direction (take-up or drop-out) and can do so more than once. The sport hill therefore estimates the probability of participation in sport at each age, conditional on having reached that age, rather than conditional on continuous participation up to that age.

Figure 1: The "sport hill" – proportion playing regular sport at each age (of those who had reached that age)

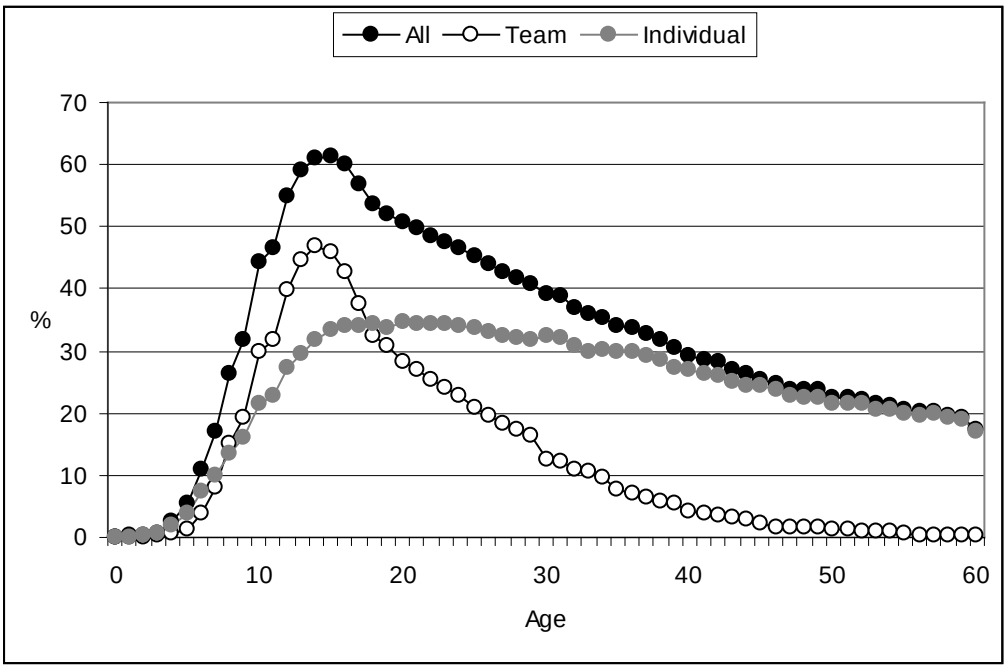


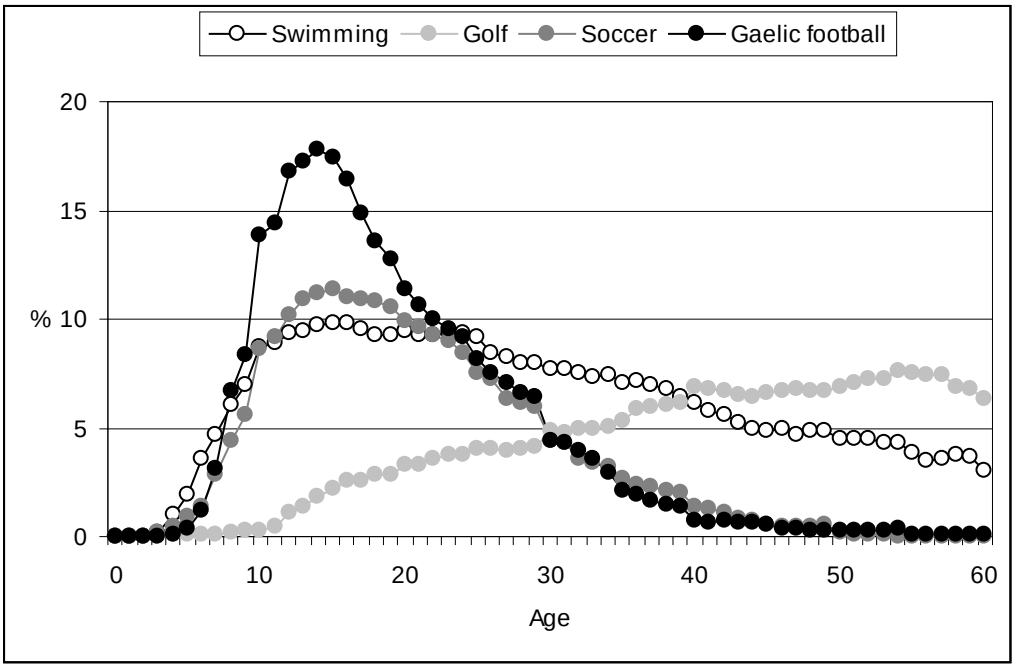
Figure 1 provides the sport hill for all sporting activity and also separate hills for team sports and individual sports. The sport hill for all sports has a distinctive shape, peaking at age 15, when over 60% of people were playing regular sport. The kink at age 11 coincides with the transition from primary to secondary school in the Irish education system. There is a sharp fall-off during the late teenage years, followed by a steady decline throughout adulthood. One notable aspect of this decline is that it is not constant, but is steepest in earlier adulthood and shallower in middle age.

This pattern can be better understood by considering team and individual sports separately. Although almost all sports can be played as team games, the distinction here is between sports that are essentially team games (football, basketball etc.) and the rest, including sports involving races (cycling, running etc.) or one-on-one

competition (racquet sports, golf etc.). Team sports are more prevalent during the years of secondary schooling, but suffer a steep decline from age 15 onwards, accounting for the fall-off in late teenage years. The playing of individual sports does not peak until age 20 and declines only gradually thereafter. The flattening out of the sport hill in middle age in part reflects the balance between team and individual sports, because the more rapid drop-out from team sports ceases to be a factor beyond age 40.

A better idea of the constituent parts of the sport hill can be obtained by examining the sport hills for specific sports. This exercise also offers some reassurance regarding the validity of the recall data. Figure 2 plots separate hills for the four most popular sports, as measured by total years of sport across the life-course. Swimming, the most popular sport by this measure, features strongly for children and falls off only very gradually during adulthood. Gaelic football and soccer share similar profiles, except that the former peaks more sharply during the years of secondary schooling before falling dramatically away. Golf, on the other hand, increases steadily in popularity to a peak at age 54. To emphasise the difference between the sport hill and a Kaplan-Meier survival curve, note that roughly half of the sport played by 40 year-olds was taken up after age 20.

Figure 2: The sport hill for the four most popular sports



If there were significant biases in people's recollections of their activity, perhaps related to norms, we might expect the shapes of the hills for separate sports to display greater commonality. In fact, they are quite distinct. The only recurring themes in the hills for different sports (including others not shown) are a kink at age 11 for sports that tend to be offered at school and the greater likelihood from 30 years onwards of transitions into and out of participation at ages divisible by five, as discussed in the previous section, which show up as slight kinks in the adult sections of the hills.

2.2 The Sport Hill by Gender and Educational Attainment

The sport hill is a useful vehicle for descriptive analysis of factors influencing participation. Figure 3 provides separate hills for males and females, again split by type of sport. These curves are quite striking. Gender differences open up at a very young age, especially for team sports. Females take up team sports later, at the beginning of the secondary school years, but then rapidly drop those same sports in their late teenage years. This effect appears to be the primary cause of the sharp decline in overall participation at this age. The picture for individual sports is very different. The gender gap is much narrower and males have higher participation only once they have begun to drop out from team sports. The gender gap for individual sports also varies across the life-course, widening in young adulthood, narrowing in the 30s, then widening again. Lunn and Layte (2008) have undertaken further analyses of these gender differences. They result from different rates of drop-out between the genders at different stages of adulthood, while the rates of taking up new sports remain, contrastingly, very similar.

Figure 3: Sport hills by gender

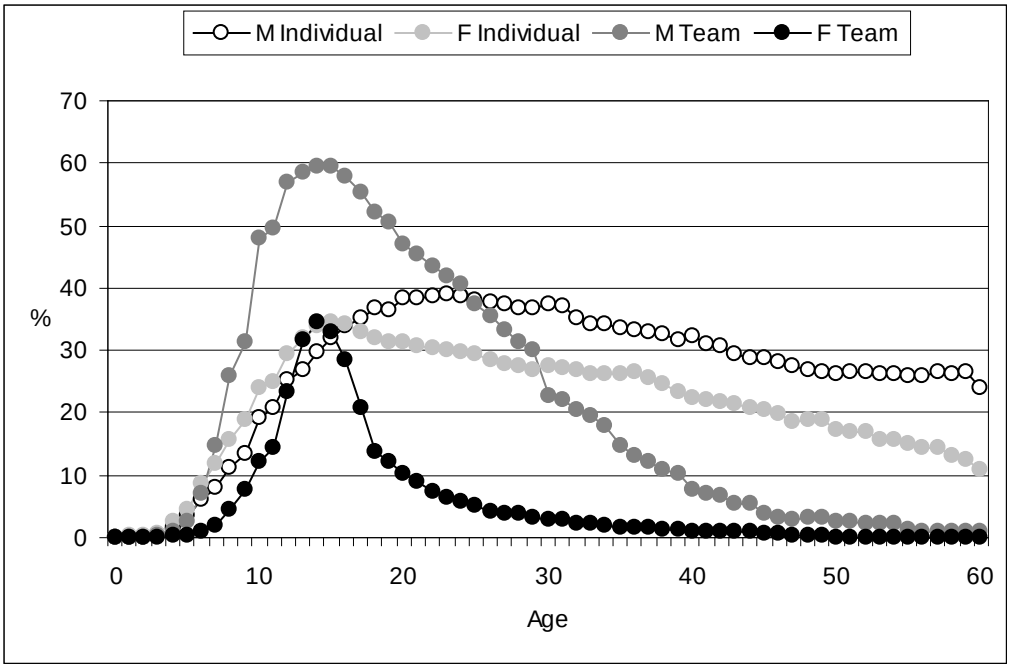
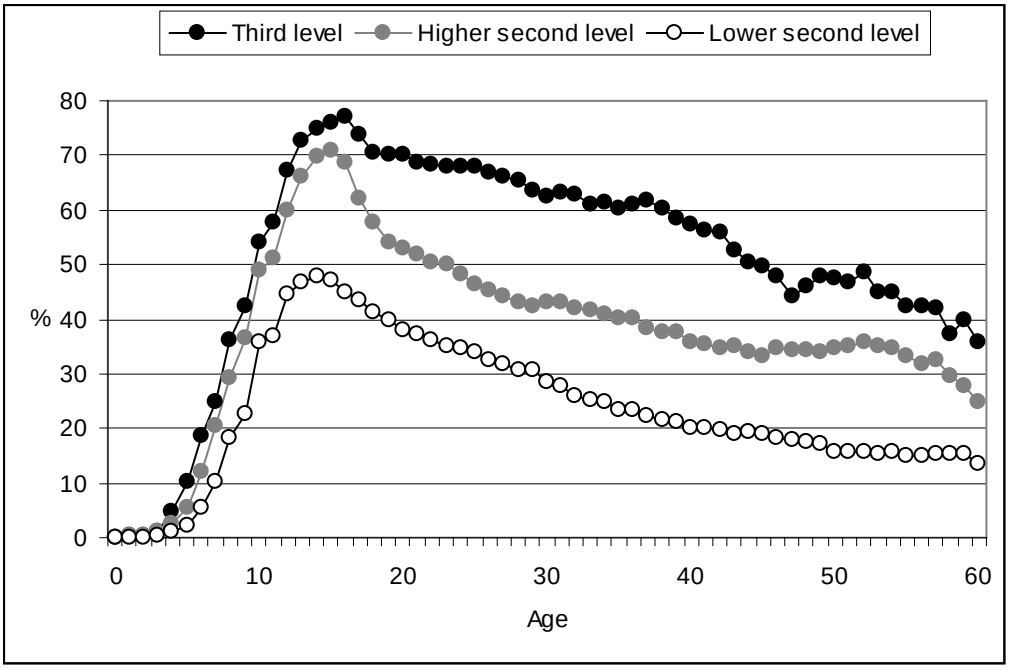


Figure 4 charts the sport hills for three levels of educational attainment, for all sports. The large differences in participation suggest that socioeconomic circumstances are also likely to be an important influence. Separate curves for team and individual sports (not shown) suggest that the effect is present for both but larger for individual sports. The participation gap in Figure 4 opens up well before the age at which the level of educational attainment recorded is actually achieved. There may be a number of separate processes involved in this relationship. Those who ultimately obtained higher levels of educational attainment may have been more likely to have had parents with the resources to support their children's sporting activity, more likely to have parents who themselves played sport, more likely to have attended better schools and, by remaining in full-time education for longer, more likely to have had convenient and subsidised access to sporting opportunities during early adulthood. All of these are indirect effects of educational attainment. Direct effects are also possible: more educated individuals may have been more likely to understand the benefits of sport and physical activity, or to act upon them. In addition, it is possible that causality runs to some degree in the other direction; that playing sport had an impact on scholastic performance, one way or the other.

Figure 4: The sport hill by educational attainment



This sort of univariate analysis is instructive regarding transition points in the life-cycle and suggestive regarding influences, but as the discussion of Figure 4 implies, it is also limited. As well as being subject to multiple interpretations, the gaps in participation rates in Figure 4 may be influenced by other factors correlated with age and educational attainment. For example, Ireland has particularly strong negative correlation between educational attainment and age – later cohorts have considerably higher average attainment. There are also correlations between gender and socioeconomic variables that could affect the participation gap in Figure 3. Nevertheless, the sport hill is very helpful for deciding what forms of regression model might be employed to disentangle some of the factors that determine participation in sport. Specifically, because participation as a child and as a young adult appears to have been strongly related to transitions into and out of educational institutions, it makes sense to model participation either side of these transition points. For this reason, Section 4 explores the determinants of having played sport at ages 15 and 20 years, i.e. at the peak of participation during secondary schooling and again once individuals have moved on from school. For adult participation, the shape of the sport hill suggests that transitions into and out of participation are no longer associated with specific transition points, but instead occur steadily throughout adult life. Given this, a time-to-event model is appropriate. Section 5 uses the proportional

hazards approach to examine separately, from age 20 onwards, the determinants both of dropping out from sport and of taking up a new sport.

4. Who Played Sport as a Young Person?

Binary logistic regression is employed to model the determinants of having participated in sport at ages 15 and 20. The dependent variable takes the value '1' for cases where the respondent was playing regularly at age 15 (20) and '0' for cases where the respondent was not. Initial models are reported for having played all kinds of sport, then separate models for team sport and individual sport.

4.1 Independent Variables

The choice of independent variables for the models is primarily informed by previous work (see Section 1), which has shown that gender, age and socioeconomic status are the background factors most strongly associated with participation in sport. Systematic model-building strategies were also tried for the whole range of available background variables (e.g. residential location, household size and composition, area type etc.), including both forward and backward step-wise selection, which confirmed that the variables most strongly associated with participation in sport are as the literature suggests. The models presented are robust to the inclusion of any of the available additional variables, which are omitted for the sake of parsimony.

In previous studies, the impact of age and cohort are confounded. That is, older people may play less sport because playing declines with age or because they belong to a cohort that plays less sport (although the effect is invariably put down to age rather than cohort). The recall method used here allows these two possibilities to be distinguished. The independent variable 'cohort' corresponds to the mean age of the sample minus the age of the respondent, in years, divided by ten. Hence, a one unit difference equates to being born one decade later and the associated odds ratio estimates the impact of being born one decade later on the odds of having played sport at age 15 (20). If the impact of cohort on participation were non-linear it would be more appropriate to make this variable categorical, or to seek an alternative

transformation of it, but employing a categorical cohort variable in the models reported suggests that the assumption of linearity is, in fact, reasonable.

Given the likelihood that attitudes to females playing sport will have changed in recent decades, an interaction term between gender and cohort is included. Interactions involving gender, cohort and each of the other independent variables were also tested, but were non-significant or only marginally significant and are omitted.

The present survey, which was specifically designed to examine sporting behaviour, also included a question about parental sporting activity. Respondents indicated whether their parents were playing any regular sport during the years when they were in secondary school. This variable turns out to be powerful and is included in all specifications.

The main variable used to indicate socioeconomic status is educational attainment. A categorical social class variable is also available in the data-set, but with the exception of the coefficient for the highest class, 'professional' (a category that is entered as a dummy variable in some of the models reported below), the variable is always non-significant once educational attainment and income are included in the model. As is often the case in household surveys, a proportion of respondents did not supply income information, so the inclusion of income as an independent variable reduces the sample. For each dependent variable, two models are reported below, one that does not include income and one that does. (If, instead, a dummy variable is added for those who did not supply income information, it is not significant.) The raw household income figure is equivalised using the modified OECD income scale (1.0 for the respondent, 0.5 for each additional adult, 0.3 for each child), logged to counter the skew of the distribution and divided by the inter-quartile range, such that one unit relates to the difference in income between the 25th and 75th percentile of the income distribution; or more intuitively, between being moderately well off and moderately badly off in terms of household income.

4.2 Models for Having Played Sport at Age 15

Table 1 presents the estimated odds ratios for having participated regularly in sport at age 15, derived from six logistic regression models. Consider first the impact of gender and cohort. Taking all cohorts together, males are roughly three times more likely to have played regular sport at age 15, although the effect is confined to team sports. More recent cohorts are also significantly more likely to have played at age 15. This cohort effect applies to both team and individual sport, but for team sports the odds ratio on the 'Male*Cohort' interaction term implies that it is almost exclusively the result of girls having been more likely to play team sport in recent cohorts.

Table 1: Odds ratios estimated via logistic regression for playing sport at age 15

	Exp(β)					
	All sport		*Team sport*		*Individual sport*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Male	2.86***	3.02***	3.65***	3.67***	0.91	0.89
Cohort	1.31***	1.31***	1.36***	1.36***	1.13***	1.11**
Male*Cohort	0.82***	0.84***	0.72***	0.74***	1.00	1.06
Parents played sport (Ref: Neither played)						
Father only	2.11***	2.05***	1.48***	1.54***	1.56***	1.42***
Mother only	1.89**	1.70**	1.65**	1.83**	1.50*	1.30
Both played	2.32***	2.58***	1.26*	1.27	2.56***	2.53***
Educational attainment (Ref = Lower 2nd level)						
No qualifications	0.58***	0.64***	0.54***	0.60***	0.61***	0.68**
Higher 2nd level	1.79***	1.77***	1.31**	1.26*	1.77***	1.88***
Third-level	2.02***	1.76***	1.33**	1.18	2.55***	2.49***
Postgraduate	2.53***	2.02***	1.21	0.95	3.24***	2.97***
Income		1.30***		1.19**		1.30***
Constant	0.60***	0.11**	0.36***	0.13***	0.27***	0.05**
N	2860	2189	2860	2189	2860	2189
-2LL	3258.6	2451.9	3497.8	2659.8	3271.0	2459.2
Nagelkerke R^2	0.24	0.26	0.19	0.20	0.17	0.19
Hosmer-Lemeshow (p-value)	0.60	0.78	0.49	0.30	0.70	0.98

(* p < 0.10, ** p < 0.05, *** p < 0.01)

There is a consistent and strong association between parent's and children's sporting activity. This applies to both team and individual sport, but the effect is largest for individual sports where both parents were playing sport. Given the age profile of parents of schoolchildren, it is more likely that the sport the parents (especially the mother) played was also an individual sport.

Turning to the socioeconomic variables, educational attainment is significantly related to having played sport at 15 years, especially to having played individual sport. Those who went on to obtain postgraduate qualifications were some three times more likely to have played at age 15 than those who obtained only lower second-level qualifications. The introduction of the income variable, which is itself significant, moderates the influence of educational attainment somewhat, but its association with having played remains highly significant for individual sports. Given that in most cases these socioeconomic indicators relate to an individual's recorded status several decades after the behaviour in question, the extent of this socioeconomic influence on participation in sport is quite striking.

4.3 Models for Having Played Sport at Age 20

Table 2 provides a similar analysis for age 20. Males are more than four times as likely to have been playing regular sport at age 20; ten times in relation to team sports, although the interaction term suggests this large gender gap has narrowed slightly in more recent cohorts. These odds ratios are consistent with and help to quantify the univariate analysis presented in Figure 3. For both genders, the period between 15 and 20 years of age is characterised by a sizeable proportion who gave up sport. But the rate of dropout was more severe for females, resulting in a much greater gender gap at 20 than at 15 years.

The estimated influence of cohort is weaker at 20 years of age. This suggests that while there has been higher participation during the secondary school years in more recent times, this increase in sporting activity has not entirely fed through to higher participation after leaving school.

There remains at age 20 a significant influence of coming from a more sporting family, although it appears that the impact of sporting mothers diminishes relative to age 15, except where both parents played sport. One potential hypothesis might relate this gender-specific change in parental influence to the widening gender gap in participation just described, but interactions between the gender of the respondent and the pattern of parent's sporting activity are non-significant (not shown).

Table 2: Odds ratios estimated via logistic regression for playing sport at age 20

	Exp(β)					
	All sport		*Team sport*		*Individual sport*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Male	4.61***	4.33***	11.02***	10.95***	1.74***	1.60***
Cohort	1.12***	1.13***	1.27***	1.23***	1.11**	1.12**
Male*Cohort	0.92	0.91	0.80***	0.81***	0.98	1.00
Parents played sport (Ref: Neither played)						
Father only	1.85***	1.77***	1.57***	1.55***	1.53***	1.40***
Mother only	1.32	1.02	1.29	1.07	1.40	1.07
Both played	2.49***	2.47***	1.34*	1.34*	2.31***	2.13***
Educational attainment (Ref = Lower 2nd level)						
No qualifications	0.75**	0.88	0.78	0.81	0.77	0.89
Higher 2nd level	1.80***	1.80***	1.23	1.11	2.04***	2.12***
Third-level	2.85***	2.61***	1.32*	1.11	3.38***	3.36***
Postgraduate	3.96***	3.37***	1.46*	1.28	4.29***	3.93***
Income		1.20**		1.05		1.27***
Professional	1.46**	1.26	2.01***	2.04***	1.31*	1.10
Male*Professional	0.61**	0.81	0.53***	0.54**	0.58***	0.77
Constant	0.26***	0.08***	0.07***	0.13***	0.19***	0.04***
N	2725	2118	2725	2118	2725	2118
-2LL	3192.0	2476.6	2666.8	2084.2	3138.1	2429.5
Nagelkerke R^2	0.26	0.26	0.28	0.29	0.18	0.19
Hosmer-Lemeshow (p-value)	0.25	0.13	0.72	0.66	0.51	0.63

(* p < 0.10, ** p < 0.05, *** p < 0.01)

At age 20, the socioeconomic variables have a stronger association with having played sport than at age 15. This finding should be treated cautiously, however, because socioeconomic indicators recorded at the time of the survey are likely to reflect status at 20 years of age more accurately than status at 15 years. Still, it is notable that belonging to a professional occupation is significant for having played at age 20. (This variable was omitted from the regressions for age 15, where it was always non-significant). Wherever this effect is significant, it is also counterbalanced by the interaction between professional status and gender, implying that the effect only applies to females.

Summarising the findings from these age-specific logistic regressions, the models give additional insights into the determinants of participation in sport identified in previous studies. The impact of gender and socioeconomic status varies considerably according to the type of sport. Socioeconomic circumstances are particularly strongly

linked with having played individual sport, while gender is a powerful determinant of having played team sport. Comparing the models at age 15 and 20 reveals that females are particularly likely to drop out from sport over this period, especially from team sport. Lastly, the models reveal that more recent cohorts played significantly more sport, both team and individual, although the cohort effect for team sport is specific to females.

5. Who Takes Up Sport and Who Drops Out?

The likelihood of participation in sport is highest among teenagers and young adults. From this peak in activity, two factors determine the level of participation during adulthood: the rate at which people take up sport and the rate at which people drop out. A proportional hazards method, Cox regression (Cox, 1972), is used to examine each of these transitions.

5.1 Appropriateness of Proportional Hazards Model

Other time-to-event estimation methods were considered, but an advantage of Cox's proportional hazards method is that it does not require the probability distribution of status changes over time to have a known parametric form. This is particularly helpful when dealing with transitions not addressed by previous research (Hosmer and Lemeshow, 1999), such as into and out of participation in sport, and also means there is no requirement to parameterise the flattening out of the sport hill in middle age, which appears from Figure 1 to happen fairly abruptly between 40 and 50 years of age. However, for the model to be appropriate, it must obviously satisfy the proportional hazards assumption: the difference in log hazard associated with a change in each covariate should not depend on time.

For all the models reported below, the proportional hazards assumption is tested for each covariate using the following method (Grambsch and Therneau, 1994; Hosmer and Lemeshow, 1999). The model assumes a log hazard function that can be expressed as a combination of the baseline hazard function $h_0(t)$, which is dependent on time, t, and the linear predictor $\mathbf{x}'\beta$, which is not:

$$\ln\{h(t,\mathbf{x},\boldsymbol{\beta})\} = \ln\{h_0(t)\} + \mathbf{x}'\boldsymbol{\beta}.$$

For each covariate, x_j, the assumption can be tested by replacing the linear predictor with

$$\beta_j x_j + \gamma_j x_j \ln(t)$$

and testing the hypothesis $\gamma_j = 0$. Equivalently, the time-dependent interaction term $x_j \ln(t)$ can be added to the proportional hazards model, which is the method adopted here, with one unit of t equating to one year of age.

5.2 Who Takes Up Sport?

The event of interest here is the taking up of a new sport after 20 years of age. The model applies to all individuals for whom there is a complete sporting history, including those who were already playing a sport at age 20, which itself enters as a covariate categorised by the type of sport played. The logic of setting t0 at 20 years of age follows the shape of the sport hill and the analyses of Sections 3 and 4, which suggest that the process of leaving school is a key transition point for participation in sport.

Table 3 presents relative rates of risk, the exponent of the coefficient, exp(□), for taking up sport after 20 years of age, derived from the Cox regressions. In addition to the explanatory variables introduced in Section 4, car ownership turns out to be significant and is included in the specification. Some 15% of Irish adults do not have access to a car and are considerably less likely to take up a sport as a result.

Gender is non-significant in these models. Males are estimated to have taken up sport marginally more quickly and it remains possible that a larger sample might find this difference to be significant, i.e. that the finding represents a type II error, but in any case the estimated influence of being male on having taken up a sport is far less than the influence of cohort and a range of socioeconomic factors. The cohort effect is highly significant: people born just one decade later are estimated to have taken up

sport at a 30% faster rate. Looking across models (1) and (2), high educational attainment, income, professional status and car ownership had strong and significant impacts on the rate at which adults took up sport. Since all these variables are correlated, a typical individual with a high socioeconomic position was several times more likely to have taken up a sport over a given period.

Table 3: Relative risk of taking up a sport after age 20, estimated by Cox regression

	Exp(β)		
	(1)	*(2)*	*(3)*
Male	1.10	1.10	1.10
Cohort	1.31***	1.30***	1.31***
Parents played sport (Ref: Neither played)			
Father only	1.06	1.00	1.06
Mother only	0.81	0.80	0.82
Both played	1.13	1.07	1.13
Educational attainment (Ref = Lower 2nd level)			
No qualifications	0.83	0.90	0.75
Higher 2nd level	1.17	1.07	0.97
Third level	1.63***	1.46***	1.68**
Postgraduate	2.00***	1.53**	2.94***
No car	0.55***	0.55***	0.55***
Professional	1.30***	1.28**	1.30***
Sporting history (Ref = Never played)			
Dropout	0.90	1.29*	1.11
Team only	1.57***	1.87***	1.73***
Individual only	1.47***	1.92***	1.63***
Plays both	1.24	1.47**	1.37
Income		1.43***	
No qualifications*Ln(year)			1.05
Higher 2nd level*Ln(year)			1.10
Third-level*Ln(year)			0.99
Postgraduate*Ln(year)			0.79
N	2,625	2,049	2,625
Event (took up sport)	666	538	666

(* p < 0.10, ** p < 0.05, *** p < 0.01)

An individual's sporting history up to age 20 is also a significant factor. Those already playing a sport took up new sports at a significantly faster rate, regardless of whether the existing sport was a team or individual sport. The effect is not as strong for those who were already playing both types of sport at age 20, which may reflect a

level of saturation in participation. Once sporting history is controlled for, having had parents who played sport is not a significant factor in take-up as an adult.

Model (3) incorporates a test of the proportional hazards assumption. In this case, $x_j \ln(t)$ is non-significant, where x_j is educational attainment. This example is chosen not only to illustrate the method, but also because it makes the interesting point that the impact of educational attainment on participation extends beyond years spent at college. One might hypothesise that individuals who went to college would have been more likely to have taken up a sport in their early twenties, but that this sporting advantage would then have diminished as they progressed through adulthood. In terms of the diagnostic test, this hypothesis would imply the relative risk on the interaction term 'Third-level*Ln(year)' should be significantly less than one and, if so, that the proportional hazards model would not be valid. In fact, the interaction terms for educational attainment are all non-significant. Furthermore, this test finding applies to all of the other covariates in the model. Based on this test, the proportional hazards model appears to be appropriate for the task.

5.3 Who Drops Out From Sport?

The same technique is next applied to having dropped out from sport after age 20, but there are two differences to note relative to the take-up analysis. First, preliminary work revealed that the gender variable fails the diagnostic test of the proportional hazards assumption ($p<0.00l$). This result is not surprising given that the sport hills for males and females (Figure 3) not only display contrasting levels but also contrasting shapes. These differences are primarily driven by different rates of drop-out at different life stages, for both team and individual sport (Lunn and Layte, 2008). In principle, one way to handle this violation of the proportional hazards assumption is to employ a time-dependent gender variable in the model specification. This approach was rejected for two reasons. First, having attempted a range of functional forms for the time-dependency, none produced a satisfactory outcome, probably because there are distinct gender differences at several points in the life-course, as Figure 3 shows. Second, many other covariates also interact significantly with gender, in apparently time-independent ways. Consequently, separate models of drop-out

were developed for males and females, for which the diagnostic test of the proportional hazards assumption was found always to hold.

Creating separate models for males and females exacerbates the second difference with respect to the take-up models. The drop-out models apply to considerably smaller samples, because half of the sample was not playing sport at age 20. Obviously, this has an impact on the likelihood of establishing statistical significance.

Table 4 provides relative rates of risk for having dropped out from sport after age 20. This time, there are no significant effects of cohort. Contrastingly, there is a continuing impact of parent's participation in sport. Individuals with two sporting parents, especially females, drop out significantly more slowly. Turning to socioeconomic effects, these are still important but less apparent than for having taken up sport. There is no clear gradient across the educational attainment categories, as was the case in previous regressions, although the highest category of 'Postgraduate' stands out as significant. Income is highly significant for males, but not for females. There was no impact of social class, nor of car ownership (not shown).

By far the most significant factor in whether people dropped out, however, is the type of sport played at age 20. Those playing only team sport dropped out at three to four times the rate for males and eight times the rate for females, compared with people who also played an individual sport (or, in the case of males, only played an individual sport).

This finding is interesting in light of the influence of sporting history on taking up new sports revealed in the previous section. Relative to someone who played no sport, an individual who played a team sport at age 20 was somewhat more likely to take up another sport, almost invariably an individual one. But relative to someone who already played an individual sport, they were no more likely to take up another sport and very much more likely to drop out. These transitions therefore go some way to explaining the relatively low correlation found between participation as a child and as an adult (Telama et al., 2005). Continuation of sporting activity frequently involves progression from team sports to individual sports in early adulthood, yet the take up

of new sports during this period of life is strongly linked to socioeconomic circumstances.

Table 4: Relative risk of dropping out from sport after age 20, estimated by Cox regression

	Exp(β)			
	Male		*Female*	
	(1)	*(2)*	*(3)*	*(4)*
Cohort	0.93	0.96	1.05	1.07
Parents played sport (Ref: Neither played)				
Father only	0.81	0.85	1.06	1.26
Mother only	1.13	0.87	0.45	0.35
Both played	0.71*	0.62**	0.40***	0.40***
Educational attainment (Ref = Lower 2nd level)				
No qualifications	0.98	0.90	0.76	0.82
Higher 2nd level	0.97	1.03	0.77	0.73
Third-level	0.72*	0.92	0.88	0.85
Postgraduate	0.43***	0.49**	0.52*	0.37**
Type of sport played (Ref = Plays both)				
Team only	3.33***	3.89***	8.00***	7.76***
Individual only	1.01	0.97	1.67	1.58
Income		0.68***		1.12
N	860	685	492	381
Event (dropped out)	343	288	187	143

(* p < 0.10, ** p < 0.05, *** p < 0.01)

6. Discussion

This paper tackles the statistical analysis of participation in sport in a new fashion and, hence, it might reasonably be judged on what new findings it reveals, as well as the solidity of such findings.

As outlined in Section 1, previous research has shown that there are strong influences of gender, age and socioeconomic status on the likelihood of playing sport. Moreover, this work has proved significant for policymakers in a range of countries, including Ireland and the UK, who have chosen to target participation programmes specifically at women, older people and lower socioeconomic groups. What does the present analysis add?

Firstly, the life-course analysis presented here identifies key transition points for participation in sport that have a lasting impact on the likelihood of continuing physical activity in later life. The years after leaving school appear to be a period when many individuals progress from team sports to individual sports, with lasting consequences. The likelihood of making this transition and hence of continuing to participate throughout adulthood is strongly linked to socioeconomic status. In most if not all countries, policymakers focus considerable efforts on trying to get children from all social groups involved in sport, in the hope that this will instil sporting habits. The analysis provided here suggests there is a pay-off to such policies, but that the pay-off is reduced by transitions that occur in young adulthood. There is therefore a good case for examining effective interventions at this stage of people's sporting lives, especially interventions targeted at lower socioeconomic groups.

Secondly, these findings suggest that the relationship between sport and gender changes across the life-course. The gender gap in childhood seems to be driven by team sport rather than being consistent across sports. Furthermore, any gender difference in the likelihood of taking up a sport as an adult appears to be small or non-existent, while males give up sport at a faster rate during early adulthood. It is difficult not to conclude from this that the relationship between sport and gender moves closer to equality once individuals enter an adult environment where they encounter greater choice and autonomy with respect to their sporting activity. The corollary of this conclusion is that females face a sporting disadvantage as children, albeit one that has lessened somewhat in recent years. Their fleeting involvement with team sports suggests a relatively poor return to efforts to involve females in such activities and raises the question of whether a greater range and choice of sporting activities might prove more popular and enduring.

Thirdly, the findings clearly indicate an increase in the amount of sporting activity in more recent decades, both of children and adults, at least in Ireland. This may surprise casual observers who note rising levels of obesity. It is important to realise that increased participation in sport and exercise does not necessarily imply increased physical activity overall. Many other factors contribute to the total of physical activity in our lives, including modes of transport, workplace activity, labour saving devices and so on. Yet the suggestion is that more modern generations of young adults have

higher participation in sport and, therefore, may continue to participate more in later in life also. For policymakers, maintaining this increased level of participation through middle age and beyond may have a significant return in terms of better health. Further analysis as to the specific activities that will appeal to current young adults as they age could be helpful in designing long-term policy to increase physical activity.

Is it possible that the findings are unique to Ireland? This seems unlikely, since the patterns contained in the cross-sectional data on sporting participation in Ireland are very similar to those recorded in other countries (e.g. Lunn, 2007; Farrell and Shields, 2002). Given the strength of the effects found in this Irish data, there is a good case for employing recall data to examine sporting behaviour in other countries.

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