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Hosting elite sport events to target recreational sport participation: an interrupted time series analysis

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ABSTRACT

Increasing sport participation by hosting elite sport events is a much-debated policy. This study evaluated the effect of hosting elite sport events on sport participation against the background of a shift in focus towards targeting recreational sport participation. We included 10 international elite sport events organised between 2000 and 2017 in the city of Rotterdam, the Netherlands. Sport-specific participation in the pastyear was obtained from abiannual cross-sectional survey. Per event, interrupted time series analyses were employed using 3 pre- and post-event measures. Data were summarised by means of random-effects meta-analyses. We tested for group differences to evaluate if events organised in the period with amore explicit aim to target recreational sport participation, and associated policies, had alarger impact. Three events concerning cycling, table tennis and gymnastics were followed by an increase in sport-specific participation 1-year after the event was organised, whereas the korfball event was followed by adecrease. The pooled effect of the 10 events did not show any change in sport-specific participation (0.2%-point (95% CI: −0.3; 0.8)). Significant group differences by period were found. More recent events targeting sport participation were followed by an increase in sport-specific participation (1.1%-point (95% CI: 0.0; 2.1)), but not for other events (−0.3%-point (95% CI: −0.6; 0.1)). No group differences were found for the number of visitors and location. Hosting elite sport events that explicitly target sport participation may increase sport participation among citizens. Longitudinal data following individuals over time are needed to support this finding.

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Sport events; sport participation; interrupted time series

BACKGROUND

Physical inactivity is an important risk factor for many diseases (Kyu *et al*. 2016) and sports participation can contribute considerably to leisure-time physical activity and health (Eime *et al*. 2015). Stimulating sports participation by hosting elite sport events, although a much-debated policy, can leave a legacy making the investment worthwhile (Hover *et al*. 2016). Increased participation in the population, in turn, may provide a wider 'pool' for talent from which professional athletes of the future can be selected. This process has been described as the 'virtuous cycle' of sport, and is often the reason why governments invest in elite sport (Grix and Carmichael 2012).

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Supplemental data for this article can be accessed here.

Theoretical frameworks suggest that hosting elite sport events may increase participation in sports activities by means of a so-called 'trickle-down' effect (Hogan and Norton 2000, Boardley 2013, Weed *et al*. 2015). The trickle-down effect describes the process by which the general population is inspired by elite sports, professional athletes and sport events, to engage in sport activities and physical activity behaviours (Weed *et al*. 2015), either directly or indirectly (Veal *et al*. 2012). Direct trickle-down effects may result from watching elites sport performances, whereby successes and the presence in the media of athletes inspire persons, and, as a consequence increase enrolment in sport activities and physical activity behaviours in the population. Indirect trickle-down effects may result from improvements in the sports infrastructure (e.g. the provision of new sport facilities or improvements made to existing sport facilities), temporal side-events organised along the main event, and an improved 'sports culture' in the city. For example, the legacy of hosting the start of the 2007 Tour de France Grand Depart in London (UK) consisted of new cycling lanes across the city (Berridge 2012), and this may indirectly facilitate the uptake of cycling among the host population.

The direct trickle-down effects fit well within theories of behaviour change, and two theoretical frameworks for elite sport events have been supported with empirical evidence. The transtheoretical model of change (TTM) was used as a framework to study the impact of major sport events in the UK (Ramchandani *et al*. 2017a, 2017b). The TTM categorises people into one of five stages based on intentions towards engagement in sport activities and actual behaviour (Prochaska *et al*. 1992). The findings suggested that people attending events were belonging to the stages closest to behaviour change (Ramchandani *et al*. 2017a, 2017b), and that progression towards more sport participation was observed following attending the event (Ramchandani *et al*. 2017a). The Theory of Planned Behaviour proposes that attitude, subjective norm and perceived behavioural control influence behaviour directly, and indirectly through intentions (Ajzen and Madden 1986). Two studies showed that the intention to participate in sport activities increased within the Australian and Canadian population after hosting the Olympic Games (Bauman *et al*. 2015, Potwarka 2015).

Although studies found positive changes in intentions following elite sport events (Bauman *et al*. 2015, Potwarka 2015, Ramchandani *et al*. 2017a), to date there is no convincing evidence that hosting elite sport events resulted in increases in sport participation or physical activity (Weed *et al*. 2009, McCartney *et al*. 2010, Annear *et al*. 2019). Weeds and colleagues reviewed the evidence on legacies of Olympic Games and sport events including 11 studies, and concluded that more robust evaluation is needed to inform the development of legacies following sport events (Weed *et al*. 2009). McCartney and colleagues reviewed 2 studies on sport participation and 5 studies on health outcomes, and also concluded that the available evidence was not sufficient to draw conclusions (McCartney *et al*. 2010). More recently, Annear summarised 3 reviews and additionally 6 newly published articles, and reported that most studies did not find evidence for sustained changes in adult physical activity following large sport events (Annear *et al*. 2019). In summary, to date there is little robust evidence on the legacy of sport events and, hence, it remains to be seen whether hosting elite sport events may increase sport participation or physical activity, and thereby result in health benefits (Weed *et al*. 2009, McCartney *et al*. 2010, Annear *et al*. 2019).

There is a growing recognition that hosting sport events could have a wide range of impacts that go beyond promoting sport participation and physical activity. Impacts outsides the sports domain include new employment opportunities, economic revenues, infrastructural improvements, neighbourhood regeneration and housing projects, and increased feelings of social cohesion and pride (Preuss 2007, McCartney *et al*. 2010, Chappelet 2012). Evidence suggests that these changes positively impact upon population heath (Solar and Irwin 2010). A comprehensive review by McCartney on major sport events included 54 studies with a wide range of outcomes (McCartney *et al*. 2010). Economic outcomes were reported by 18 studies, but the long-lasting impact of hosting events on economic growth and employment remained unclear. Four out of the five included studies showed that the restriction of car use and promotion of public transportation during major events were associated with short term reductions in traffic volume, congestion or air pollution. However, negative impacts such as economic losses and inflation were also reported in

some studies. Again, the authors concluded that high quality evidence is needed to predict positive and negative impacts from hosting sport events.

The only study that used a longitudinal design was the ORiEL study, aimed at evaluating the impact of the urban regeneration associated with the London 2012 Olympic Games (UK) on adolescent physical activity, mental health and well-being (Smith *et al*. 2012). After 18 months of follow-up, no differences were found in physical activity between adolescents living in the intervention borough (where the majority of urban regeneration activities took place) as compared to those living in comparison boroughs (Cummins *et al*. 2018). Urban regeneration and the Olympic Games had no impact on depressed persons, and on well-being. Also this study with high quality data could not show that physical activity increased or that health impacts were achieved following the hosting of elite sport events.

Recently, it has increasingly becoming the focus of attention that long term planning and supportive activities are needed to achieve any impact from hosting sport events (Weed *et al*. 2015, Thomson *et al*. 2019). The majority of past events did not explicitly aim to promote sport participation (Weed *et al*. 2009, Mahtani *et al*. 2013), but were mainly hosted to generate economic revenues. Likewise, most studies evaluating sport events focused on the economic impact, and less often included outcomes relevant for public health (McCartney *et al*. 2010). It remains unknown if we can expect a sport legacy of hosting sport events that aimed to promote recreational sport participation and physical activity in the population.

The city of Rotterdam, the Netherlands, has a rich history of organising major sport events. The aim of hosting elite sport events shifted from a city-marketing perspective (2000–2009), to a more health-oriented perspective (2010–2017) (City of Rotterdam 2001, 2009, 2016). From 2010 onwards, policies were implemented aiming towards more engagement of citizens (Rotterdam Festivals 2010, de Groot *et al*. 2012). First, events were more often organised within the city centre to attract more visitors. Second, an increasing number of side-events were organised along the main events to introduce the sport to visitors, and to city residents. To our knowledge, no study has yet evaluated whether sport events that aimed at increasing sport participation were more likely to do so, as compared to events that were mainly organised for other purposes.

This study aimed at evaluating the effect of hosting elite sport events on recreational sport participation among citizens. Our secondary aim was to evaluate if the shift in focus towards sports participation resulted in higher sport participation in more recent events.

METHODS

Elite sport events

The Rotterdam Topsport Foundation (a foundation funded by the city government for the support of local elite clubs and the acquisition and organisation of elite sport events) provided information about large international elite sport events hosted between 2000 and 2017. This included World Championships (WC), European Championships (EC), and other major events that were organised once in the city of Rotterdam, the Netherlands. Annual events were not included, because these events could not be related to changes in sport participation across a specific time-point. Soccer events were also not included, since soccer receives much media attention throughout the year. Events that attracted at least 5000 visitors were considered for inclusion; 22 events were identified. We excluded events without sport-specific participation data for 3 measurement rounds before and after the event (n = 8), and events with the smallest number of visitors that promoted the same sport (n = 4). Accordingly, changes in sport-specific participation were related to 10 singular elite sport events.

Events targeting sport participation

Since 2010, all elite sport events hosted in the city of Rotterdam and funded through the event funds are accompanied by side-events along the main event for the purpose of creating societal impact. In

the bidding phase, event organisers need to provide a detailed plan how sport participation in the population will be targeted, and they are requested to budget a minimum of 10% of the total requested amount from the municipality (or a minimum of €7500) for the organisation of side-events. Funding is only provided if these criteria are met.

For events before 2010 the aim to increase sport participation, and forthcoming actions including the organisation of side-events, were not documented given that it was not a policy goal for the organisation of sport events prior to 2010. Therefore, we could not separate events that targeted increasing sport participation from those primarily interested in generating economic benefits and city marketing. We categorised events by year, and separated events organised in the period without a specific aim to target sport participation (before 2010) from events organised in the period with this aim (2010 onwards).

Study design

For each event, interrupted time series analyses were employed to evaluate if events significantly interrupted the underlying time trend in the percentage of people participating in that specific sport. Sport participation data over the past year were obtained from a biannual cross-sectional survey. Data were used from 6 measurement waves around the time the event was organised. We assumed that events would result in an immediate change in the level of sport participation measured in the next round of data collection, which was, on average, 1-year after the event. For events that significantly changed sport-specific participation levels after 1-year, we examined if the change sustained up to 5-years after the event.

Study population

The cross-sectional biannual leisure-time survey among citizens of Rotterdam [in Dutch: *Vrijetijdsonderzoek*] was used to obtain sport participation data from 1995 until 2017. Under the Dutch law for medical scientific research with human subjects, questionnaire surveys are not subject to approval by an institutional ethics committee. Participants were randomly selected from the municipal registration database. Respondents were informed that by filling out the questionnaire permission was given to use the data anonymously for research purposes. All surveys included questions on demographics, leisure-time related topics, and a dedicated section on sport participation.

During 12 measurement waves, a total of 136,696 subjects were invited to participate in the survey, and 35,587 subjects returned the questionnaire. Response percentages declined from 47% in 1995 to 15% in 2017 (supplemental table 1). In two surveys by design, half of the participants did not receive questions on sport participation (n = 6,287 subjects), and those were excluded. The total study sample for analyses included 27,235 participants aged between 16 and 75 years old for which data on age, sex, ethnicity, income, city district and sport participation were available (supplemental table 1).

Sport participation

A standardised questionnaire [in Dutch: *Richtlijn Sportonderzoek]* was used to ask for any sport participation over the past year. Participants could tick multiple boxes from a list of sports. The list was updated over the years, and included indoor, outdoor, organised, and un-organised activities. Sport-specific participation included multiple sport activities for cycling (all recreational types of cycling), judo (all defensive sports), sailing (all water sport activities, but not swimming or rowing), and short track (all ice skating activities).

Socio-demographic variables

Age, sex, and ethnicity were derived from the municipal registration database. Ethnicity was based on the country of birth and classified as Western, and non-Western, following the definition used by Statistics Netherlands (Statistics Netherlands 2010). For each survey, the social minimum income and modal income in that specific year was used as the reference to classify self-reported household income into low (below social minimum income), mid-low (social minimum to modal income), mid-high (modal to 2x modal income), and high (>2x modal income).

Statistical analyses

We used an interrupted time series design that allowed to evaluate the change in sport-specific participation for 1, 3, and 5 years after the event, as compared to the trend in sport-specific participation for the 5 years before the event. For example, we evaluated if the percentage of people who played tennis in the population changed after hosting the Davis Cup Semi-final, as compared to the trend in tennis participation for the 5 years before the event. We used linear multivariable regression models adjusted for the pre-event trend in sport-specific participation, and individual-level characteristics age, sex, income and ethnicity. From this model we obtained the absolute change in sport-specific participation following events expressed as percentage points. The models were run separately for each event. We visualised the pre-event trend and the absolute change in sport-specific participation following events. Details about the model specification can be found in the additional file 2.

We quantitatively summarised the data by using random-effects meta-analyses (Hedges and Vevea 1998), with the effect of each event weighted by the inverse of its variance. Heterogeneity between events was evaluated with the I^2 test statistic (Higgins and Thompson 2002). Forest plots were made to visualise the results.

We tested for group differences to evaluate if more recent events with the explicit aim to target sport participation had a differential effect on sport participation. More specifically, we tested for differences for events targeting sport participation (no (before 2010) *vs* yes (2010 onwards)), the number of visitors (based on the median: <37,500 *vs* ≥37,500), location (city centre *vs* stadium in outskirts), and side-events (yes *vs* no).

We conducted a falsification test in which we estimated what the change in sport participation would have been in the hypothetical scenario that events organised before 2010 would all have taken place in 2010. For each event organised before 2010, we run a model in which we set the year of the event at 2010, and evaluated what the effect on sport-specific participation would have been if the trend in sport-specific participation was interrupted in 2010. This ensured that an observed effect for events organised from 2010 onwards was not reflecting the increase in sport participation seen in the population (Volksgezondheidenzorg.info 2020). We expected to find no statistically significant intervention effect in this falsification test.

Two sensitivity analyses were conducted. First, we additionally included events with sport participation data available for at least 1 pre-event measure and 1 post-event measure around the time that the event was organised. Second, we excluded one event at a time from the analysis to verify if the results were attributable to a single event.

All analyses were conducted in SPSS version 24. The data were summarised in R version 3.4.1, using the forest plot package.

RESULTS

Characteristics of sport events

Table 1 presents the description of 10 singular elite sport events hosted in the city of Rotterdam in the period 2000 to 2017, and the 4 events additionally included in sensitivity analyses. This included

Table 1. Sport events organised in Rotterdam, the Netherlands between 2000 and 2017.

Sport	Event	Period (duration)	Location	Number of visitors	Dutch result
Tennis	Davis Cup Semi-final	September 2001 (3 days)	Indoor hall Ahoy	30,000	Loss (2–3)
Korfball	World Championship	November 2003 (9 days)	Indoor hall Ahoy	20,000	Finals (gold)
Baseball	World Championship	September 2005 (16 days)	Baseball stadium Neptunus	134,000	Semi-finals (4th place)
Sailing	Ocean Race	June 2006 (1 day)	City centre	500,000	Gold for a Dutch boat
Hockey	Men's World Champions Trophy	June 2008 (9 days)	Hockey stadium HC Rotterdam	40,000	Semi-finals (bronze)
Judo	World Championship	August 2009 (5 days)	Indoor hall Ahoy	26,900	1 gold, 2 silver
Cycling	Tour de France Grand Depart	July 2010 (4 days)	City centre	1,000,000	No medals
Gymnastics	World Championship	October 2010 (9 days)	Indoor hall Ahoy	46,100	1 silver
Table tennis	World Championship	May 2011 (8 days)	Indoor hall Ahoy	35,000	No medals
Equestrian sport*	European Championship Dressage	August 2011 (5 days)	Dressage arena Kralingse bos	55,000	2 gold, 1 bronze
Squash	World Championship	October-November 2011 (10 days)	Indoor hall Vitoria; Finals in the city centre	7500	No medals
Volleyball*	Women's European Championship	September 2015 (9 days)	Indoor hall Ahoy	26,500	Finals (silver)
Rowing*	World Championship	August 2016 (9 days)	Willem-Alexander Rowing Complex	19,800	No medals
Short track*	World Championship	March 2017 (3 days)	Indoor hall Ahoy	25,000	2 gold, 1 silver, 1 bronze

* Included in sensitivity analyses

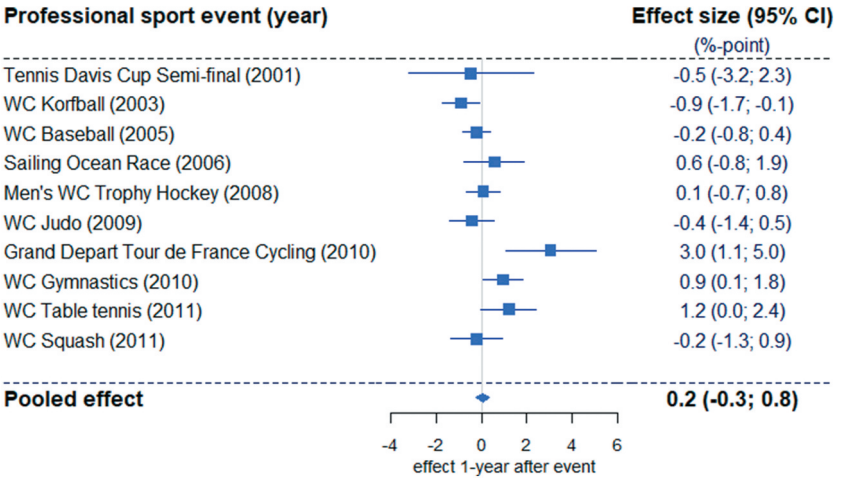

Figure 1. Forest plot of the effect of 10 elite sport events on sport-specific participation 1-year after the event took place. Analyses were adjusted for the pre-event trend and age, sex, income and ethnicity. Blue squares indicate the point estimate for each event, with the horizontal lines representing the 95% CIs. The pooled effect of the 10 events was obtained using random-effects meta-analyses, with the effect of each event weighted by the inverse of its variance. The pooled effect is indicated with the diamond, and the width of the diamond corresponds with the 95% CI of the pooled effect. Abbreviations: World Championship (WC); European Championship (EC).

9 WCs, 2 ECs, the Davis Cup semi-final tennis, the Ocean Race, and the Tour de France Grand Depart. The number of visitors ranged between 7500 of the WC Squash in 2011 and 1 million spectators at the 2010 Tour de France Grand Depart. During these 14 events, 15 medals were won by the Dutch team of which 7 were golden medals.

Effect on sport participation

The pooled effect of the 10 events did not show any change in sport-specific participation 1-year after the event took place (0.2%-point (95% CI: −0.3; 0.8)) (Figure 1). Heterogeneity across events was substantial (I^2 = 65%). Three events on cycling, gymnastics, and table tennis were followed by an increase in sport-specific participation 1-year after the event was organised, as compared to the pre-event period (Figure 2). The 2010 Tour de France Grand Depart had the largest impact. The number of cyclists increased by 3.0%-point (95% CI: 1.1; 5.0) following the event, and remained higher the years after the event. The increase in the participation of gymnastics and table tennis did not sustain. To the contrary, participation in korfball changed by −0.9%-point (95% CI: −1.7, −0.1) following the WC, and remained lower the years after the event. The results for events that were not followed by an increase in sport participation are presented in supplemental figure 1.

Group differences by aim of events

There was a significant difference between events according to the period in which they were organised (Table 2). Events organised from 2010 onwards in which the more explicit aim was to target sport participation were followed by an increase in sport-specific participation of 1.1%-point (95% CI: 0.0; 2.1), whereas no change was observed for events organised in the period without this specific aim (−0.3%-point (95% CI: −0.6; 0.1)). Substantial heterogeneity remained for events organised after 2010 (I^2 = 69%). The change in sport participation did not differ by number of visitors or location of the event.

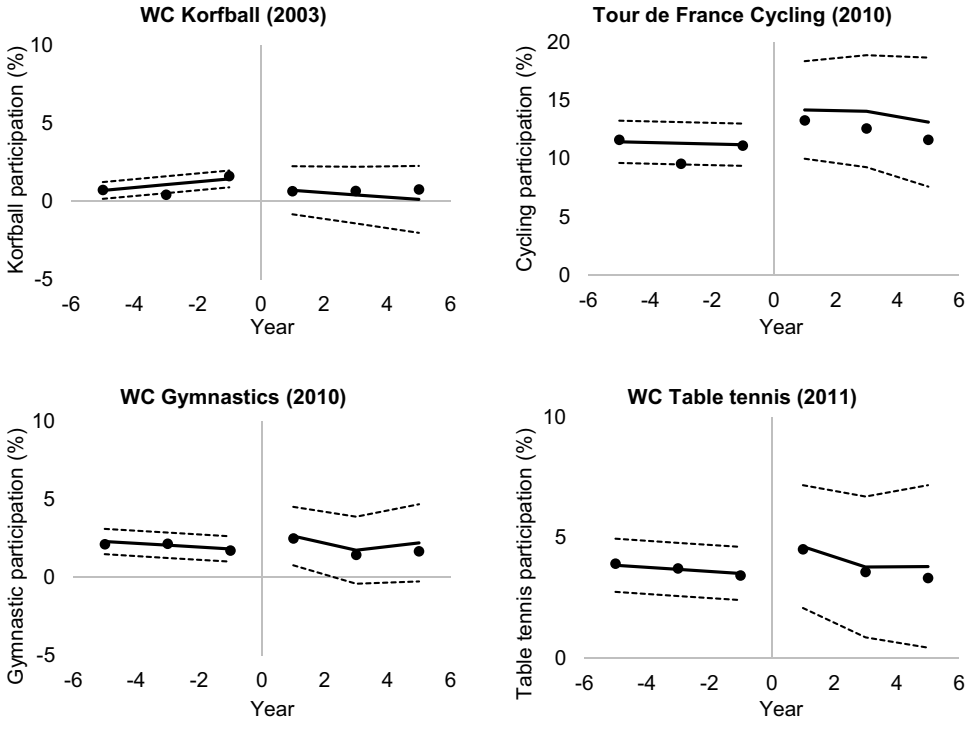

Figure 2. The sustained effect on sport-specific participation (% in the population) of events that significantly changed sport-specific participation 1-year after the event was organised. The population estimates (points) and results of the interrupted time series analyses (lines) are given. Dashed line represents the 95% CI around the estimate. Analyses were adjusted for the pre-event trend and age, sex, income and ethnicity. Year = 0 indicates the year that the event took place. Abbreviations: World Championship (WC); European Championship (EC).

The result of the falsification test indicated that the increase in sport participation seen for events organised after 2010 was not reflecting the increase in sport participation seen in the population (supplemental figure 2).

Sensitivity analyses

The findings were robust to sensitivity analyses with inclusion of 4 events with fewer data (supplemental figure 3 and 4, supplemental table 2). Excluding single events indicated that the Tour de France Grand Depart and the WC Korfball contributed most to the findings. The pooled effect of all events together slightly increased after exclusion of the korfball event (0.4%-point (95% CI: −0.2; 0.9)). The main finding that events organised from 2010 onwards were followed by an increase in sport-specific participation slightly attenuated after exclusion of the cycling event (0.7%-point (95% CI: −0.1; 1.5)) (supplemental table 3).

DISCUSSION

Three out of the 10 events were followed by an increase in sport-specific participation 1-year after the event was organised, and one was followed by a decrease. Only for the cycling event, the number of cyclists remained elevated up to 5-years following the event. The pooled effect of the 10 events, however, did not give evidence that sport-specific participation changed. Subgroup analyses suggested that only for events organised in the period in which the more explicit aim was to target recreational sport participation, an increase in sport-specific participation in the host population was

Table 2. The effect of elite sport events on sport-specific participation, stratified by indicators related to the policies that aimed to increase sport participation following events.

	Events (n)	Sport-specific participation (95% CI) (%-point)	Heterogeneity (I^2 (%))	Group difference (P-value)
Targeting sport participation				0.039
Yes (after 2010)	4	1.1 (0.0; 2.1)	69	
No (before 2010)	6	−0.3 (−0.6; 0.1)	0	
Number of visitors				0.19
≥37,500	5	0.6 (−0.2; 1.4)	73	
<37,500	5	−0.2 (−1.0; 0.6)	54	
Location of the event				0.34
City centre	3	1.0 (−0.8; 2.8)	78	
Stadium in outskirts	7	0.0 (−0.5; 0.6)	62	

Analyses were adjusted for the pre-event trend and age, sex, income and ethnicity. All effect estimates were pooled effects obtained from random-effects meta-analysis, weighted by the inverse of its variance.

observed. The result of the falsification test increased our confidence that we were capturing the effect of hosting elite sport events rather than time trends in sport participation.

The finding that sport events with the more explicit aim to target sport participation were followed by an increase in sport-specific participation is a novel finding. Existing evidence showed little impact of multi-sport events such as the Olympic and Paralympic Games on sport participation and physical activity (Weed *et al*. 2009, McCartney *et al*. 2010, Cummins *et al*. 2018, Annear *et al*. 2019). Mega-events may be less (financially) accessible by the host population. It is promising that sport-specific participation rates increased after organising sport events, but longitudinal data following individuals over time are needed to identify if people increased their physical activity levels.

The ORiEL study is the only study to date that evaluated the sport legacy of the London Games in 2012 by following people over time, but did not find evidence of an impact on adolescents physical activity, mental health or well-being (Cummins *et al*. 2018). Qualitative research revealed that health was less of a priority in relatively deprived areas in which the study was conducted than more immediate concerns such as employment, safety and housing. This indicates that not all subgroups of the population may be able to benefit from sport events, and additional research is warranted to identify population subgroups that are impacted from hosting sport events.

In our study, events targeting cycling, gymnastics and table tennis were followed by an increase in sport participation among adults. Most notably, we found that the number of cyclists remained higher up to 5-years following the event. Possible reasons are that a large-scale awareness campaign started 100-days before the event took place, reaching a large part of the population, and the fact that it is relatively easy and safe to start recreational cycling in the Netherlands (Pucher and Buehler 2008). Cycling also fits within the current era in which people prefer to sport individually (van den Dool 2019). Interestingly, the routing of the time trail elites cycled in 2010 is still clearly signed in the city centre. Finally, other major cycling events were organised after 2010 in the Netherlands. The continued attention of the cycling sport in the media may have contributed to the sustained increase in cyclists.

For the other two events, an increase in sport participation was observed only directly following the gymnastic and table tennis event. Prolonged promotional activities may be needed to achieve sustained behavioural change. Furthermore, it may require more actions to increase sport participation for sports that are less accessible, and less embedded within the sports culture of a population. Further research is needed to identify what type of sport events have the highest potential to boost sport participation in the population.

The organisation of the WC korfball decreased sport participation. A possible explanation is that so-called 'discouragement effects' may have appeared if the performance levels were perceived as unattainable (Hogan and Norton 2000). However, this may have occurred for all elite sport events under study, and therefore unlikely explains the contradictory finding. Another possibility is that the image of korfball

decreased after the WC, because of the Dutch team winning all matches with large results. Alternatively, some measurement error could be present. We observed an increase in any type of sport in the year 2003, most likely due to random sampling error. Therefore, measurement error is a likely explanation of the finding that sport participation decreased following the WC korfball hosted in 2003.

A systematic review by Weeds and colleagues of 21 studies evaluating trickle-down effects resulting from the inspiration by elite sports, professional athletes and sport events concluded that a trickle-down effect was unlikely to engage new persons into sport activities, but that those already active may have increased their sport frequency or switched from activity (Weed *et al*. 2015). In our study, we lacked information on frequency of sport participation. The review also indicated that the trickle-down effect will mostly influence people with positive attitudes towards sport activities (Weed *et al*. 2015). We found the largest impact on sport participation levels following the Tour de France Grand Depart. It is likely that Dutch citizens have a positive attitude towards cycling given that cycling is one of the main modes of transportation (Pucher and Buehler 2008, Fishman *et al*. 2015).

The inspirational function of elite performances, and the presence of professional athletes in the media when hosting events have also been suggested to be of importance. To date, there is only limited evidence of the trickle-down effect through elite success (Hogan and Norton 2000, De Bosscher *et al*. 2013, Weed *et al*. 2015, Frick and Wicker 2016, Wicker and Frick 2016). In our study, we could not evaluate whether success by Dutch athletes in events hosted in the city of Rotterdam contributed to a larger increase in sport participation in the population. In the current study, we could only compare performances across sport disciplines. The expected gold medal at the WC korfball have had little impact on korfball participation in the population, while some increases in gymnastics were seen following the unexpected silver medal during the WC gymnastics. Furthermore, we see that the Dutch team performed well in most events, which is not surprising given that decisions to host an event to some extent will rely on perceived importance and interest to the general population. The selection of events mirrors the events where typically medals are won by Dutch athletes during international tournaments. Without interest by the general population, there will be minimal economic spin-off, city marketing and changes in recreational sport participation in the population.

Strengths and limitations

This study was strengthened by the inclusion of multiple events, and we summarised the findings to generalise the results. The use of an interrupted time series design allowed to account for the pre-event trends. Sport participation estimates were taken from a single survey always conducted in September, which increases comparability of the estimates found. Sport participation was not restricted to memberships of sport clubs, but included all self-reported physical activity behaviours over the past year.

This study also had some limitations. There was no information on the frequency and duration of the sports performed. Ideally, a comparison group was included to control for time-varying factors that may have affected sport participation, but there were no data available for other cities that covered a similar period. A difference-in-difference design using sport-specific participation rates for sports that were not targeted by an event may be an alternative, especially when focusing on single events. However, as we studied multiple events combined the selection of a single control group for multiple events would not be possible. Furthermore, we could not use major sports as a control, since events were related to major sports. In absence of a control group, we conducted a falsification test. The result from the falsification test strengthened our believe that we are capturing the effect of hosting elite sport events. We selected 3 data points to correct for the pre-event trend, but more data points are needed to be more precise. Sport participation data were collected biannually, thus short term changes could not be detected. The decline in response may have influenced external validity, but the influence on sport participation in the population is expected to be small. In our analyses we focused on adults, however, earlier research indicated that children and adolescents might have

been a better population for promoting physical activity following sport events (Carter and Lorenc 2013, Wicker and Sotiriadou 2013). We had no information on intermediate outcomes or on the mechanism how the events contributed to changes in sport participation.

Future recommendations

In this study we found some evidence that a city with a clear ambition to target sport participation via the hosting of elite sport events may influence sport participation among the general population. A careful selection of the type sport activity promoted through hosting elite sport event seems important, given that not all events were followed by an increase in sport participation. The increase is likely to occur among people with a positive attitude towards sport in general, or towards the specific sport activity promoted through the event. Furthermore, the sport infrastructure in a city must allow for a potential increase in sport participation. Funding for the development of programmes and side-events targeting sport participation before and after the event is critical to ensure a sustained increase in sport participation. It is important to monitor potential changes in the city that influence sport development and participation to inform future policy-making. Longitudinal data following individuals over time are needed to provide evidence whether more people become physically active, or that people shift between sports. It is essential to identify the type of activities needed to reach specific subgroups of the population, and to identify the elements of these activities that contribute to increasing sport participation.

CONCLUSION

Hosting elite sport events that specifically target sport participation in the general population may increase levels of sport participation among citizens. Not all events were followed by an increase in sport participation, therefore the type of event needs to be carefully selected. To capture the sport legacy of future elite sport events, it is important to study whether inactive people take up sport activities, if those already active increases the frequency of sport activities, or that people switch between sports.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the City of Rotterdam, but restrictions apply to the availability of these data, which were used under license for the current study, and are not publicly available. Data are however available from the authors upon reasonable request and with permission of the City of Rotterdam.

Ethics approval and consent to participate

Under the Dutch law for medical scientific research with human subjects, questionnaire surveys are not subject to approval by an institutional ethics committee. Respondents were informed that by filling out the questionnaire permission was given to use the data anonymously for research purposes.

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Authors' contributions

Ms. Famke Mölenberg conceptualized and designed the study, carried out the analyses, drafted the initial manuscript, and reviewed and revised the manuscript. Dr. F. de Waart, Prof. Frank J. van Lenthe and Prof. Alex Burdorf conceptualized and designed the study, and reviewed the manuscript. All authors read and approved the final manuscript.

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