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**Are Athletes on the Right Track? The Effect of Availability
of an All-Weather Athletics Track on Athletics Performance**

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Are Athletes on the Right Track? The Effect of Availability of an All-Weather Athletics Track on Athletics Performance

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Abstract: In February of 2011, an earthquake destroyed the only all-weather athletics track in the city of Christchurch (New Zealand). The track has yet to be replaced, and so since the loss of the track, local Christchurch athletes have only had a grass track for training and preparation for championship events. This paper considers what effect the loss of the training facility has had on the performance of athletes from Christchurch at national championship events. Not surprisingly, the paper finds that there has been a deterioration in the performance in events that are heavily dependent upon the all-weather surface. However, somewhat more surprisingly, the loss of the track appears to have caused a significant improvement in the performance of Christchurch athletes in events that, while on the standard athletics programme, are not heavily track dependent.

Keywords: sports economics, athletics facilities

JEL Classification: Z2, C4

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1. Introduction

In the mid-1960s, a significant change occurred in the technology of athletics track surfaces. Whereas previously, surfaces were mainly made of compacted cinders, or perhaps grass, the new prototype of track was constructed out of rubber-based (synthetic) materials. The benefits of the new track surfaces were immediate; they were able to be used equally well in all weathers (rain or shine, and hence they are often called “all weather” surfaces) whereas cinder or grass surfaces suffered significant deterioration (to the point of becoming unusable) in wet weather, they had vastly superior shock-absorbing effects upon runners’ legs (leading to fewer injuries), and they had much lower maintenance costs over time. The generally accepted view held that the new synthetic surfaces also lead to notable improvements in the performances of athletes, due mainly to the “energy-return” springboard effect of rubber compared to cinders or grass.¹ The last Olympic games to be held on a non-synthetic surface was in Tokyo in 1964, and since about the early to mid-1970s, synthetic athletics tracks have been a standard requirement for hosting all athletics meetings, from fully international events right down to local school championships. Almost all major cities around the world have one, or even several, synthetic tracks, and in many countries these tracks are also standard at universities and high-schools.

Notwithstanding the accepted benefits of synthetic tracks over the surfaces that preceded them, as far as we are aware there has been no research that investigates the validity of the claim that a synthetic surface leads to better athletic performances as compared to cinder or grass surfaces.² There may be several reasons for this, but surely the leading issue is the difficulty in running a controlled test where everything except for track surface is held constant. The change in track surface historically happened precisely at the same time as steroid use in athletics became common. Track shoe technologies also changed along with the track surfaces and, perhaps most importantly, at around the same time athletics became largely professional. Separating out the effect of track surface becomes an almost impossible task.³

Not only is it possible that athletes register better performances when they run on a synthetic surface track as opposed to other materials, but the availability of such a facility should more generally stimulate athletic talent. It seems reasonable that athletes who have the ready use of a modern facility are able to train better, race better and more often, and suffer fewer injuries. All of these effects should translate into overall better prepared and perhaps more enthusiastic athletes. For example,

¹ A common, but not too scientific method of measuring this is to drop a golf-ball from shoulder height onto the surface. The more it bounces, the greater is the energy-return of the surface. One can easily imagine how much higher the ball would bounce from a springy rubber surface as compared to bare dirt or grass.

² See <http://www.cosmosmagazine.com/features/the-technology-athletics-tracks/> for a discussion on this point, and references to some early work comparing indoor track surfaces, which were originally made of wooden planks but more recently are made of the same rubber-based material as modern outdoor tracks. More recently, a study by Amy Kerdok and colleagues calculated that tracks made of polyurethane produced improvement in running speeds by two to three percent and decreased the number of running-related injuries by 50 percent, compared with track surfaces made of other materials (Kerdok et al., 2002). Most claims from local athletes in Christchurch are that the grass surface they currently are forced to use costs them between one and two seconds per lap run. Assuming laps of about 60 seconds, the Kerdok et al. (2002) calculation of two to three percent would imply a time loss of between 1.2 to 1.8 seconds per lap. However, the Kerdok et al. study did not actually compare performances on rubber surfaces with performances on grass in particular. See also the paper by McMahon and Greene (1979), who compute that an optimally designed track can improve performances by between 2 and 3 percent.

³ Not only is this problematic using historical data, but even if tests were run on both surfaces, it would be necessary to control for such things as weather and wind conditions, and for the physical and mental condition of the athletes on each trial.

McMahon and Greene (1978) point to the advantage of the availability of a high-quality track surface becoming apparent during training, when athletes can maintain higher speeds compared to what is possible on other surfaces. This aids in the development of the neuromuscular control and physiological adaptations that are necessary to compete at the highest possible levels.

The research question that we undertake in this paper is to try to measure the effect upon performance of athletes of the availability of a synthetic athletics track. In particular, we note that the present study does not attempt to answer the question of how much better athletics performances are on an all-weather surface as compared to other surfaces. Rather, we are interested in the more general effect of availability of an all-weather surface upon athletic talent.

This question is not trivial. The obvious benefits of the availability of an all-weather synthetic track are several. A short-list could include the following: (1) since competitions are not cancelled because of adverse weather, there are more opportunities to run fast thereby achieving qualification times, and generally maintaining enthusiasm and confidence, and thereby participation, (2) there is a greater choice of training environments, leading to more flexible training regimes, and (3) the smooth consistent surface, which offers much better traction and cushioning when compared to other surfaces, leads to a reduced risk of injury. On the other hand, there may also be a countervailing effect in that only having a grass track for both training and competition may build up physical and mental toughness, thereby giving athletes an advantage when they do get onto a synthetic surface for championship competitions.⁴

2. The case of Christchurch (New Zealand)

A new all-weather synthetic track was built in Christchurch in 1973 at Queen Elizabeth the Second (QEII) park, for use at the 1974 Commonwealth Games. The facility was very well maintained over the years, with a full re-surfacing (in a more modern material) taking place in the early 1990s. The stadium was constantly used as the main athletics venue in the South Island, for local championships (including national championships) at all levels. It was also used for weekly inter-club athletics meetings during the summer months, and for high-school championships. The track was open daily for the purposes of training of local athletes. QEII was the only track in New Zealand that was fully certified by the International Association of Athletics Federations (IAAF).⁵

The track at QEII park was destroyed in the earthquake that hit Christchurch in February of 2011. Since that time, the only track available in the city is a grass surface (Rawhiti Domain),⁶ which has taken over the role of a training venue, the inter-club venue, and the venue for some local school championships. No major championship has taken place on the grass track venue, even at the level of children's events. The track surface is maintained in a rudimentary fashion by the local city council rather than by a specialist groundsman. However, the venue at Rawhiti Domain does have newly installed modern synthetic surfaces for almost all field events (all jumping events and throwing events). Having no protecting stadium around the track means that the venue is at the mercy of the

⁴ Interestingly, in an article about the 2012 Olympic 400m champion, Kirani James (from Grenada, where there are no all-weather tracks), the Wall Street Journal suggest that training on grass may be of benefit to athletes. See the article at <http://www.wsj.com/articles/SB10001424052702303768104577462681286183966>

⁵ IAAF certification (which controls for a myriad of dimensional measurements of the track) allows a track to be used for IAAF sanctioned international events. World records are normally only ratified by the IAAF if they are made on certified tracks.

⁶ The track at Rawhiti Domain was originally (in the 1950s) constructed in cinders. The high maintenance costs of that track lead to it being resurfaced in grass in the early 1980s.

prevailing winds that are so common in coastal areas (Rawhiti Domain is located only about one kilometre from the coast). This is a compounding negative effect for running events.

The research question undertaken in this paper is the following; has there been a deterioration in performance of local Christchurch athletes due to the loss of the synthetic track?

There are several effects to take into account:

1. There may be a general effect as the population of the city changed (i.e. perhaps good athletes moved away). This effect should, in principle, affect all events in a similar fashion.
2. The loss of the track would likely have a different effect upon different events, according to the dependency of the event upon a track for training and preparation. For example, the throwing events in particular should be relatively immune to the loss of the track,⁷ while in principle the most effected events would be sprints and hurdles (including relays).

To test this, we used data from the New Zealand National Schools Athletics Championships. We used the championship results from the 3 years immediately prior to the loss of the track (2008-10), and also from the 3 years immediately after the loss of the track (2011-13). We look at the performance of athletes from schools in the Christchurch area, and we study whether the exogenous shock of the loss of the stadium has had an effect upon their performance compared to athletes from non-affected areas.⁸ For each event on the programme (except for events for disabled athletes), we monitored the performance of all athletes, and we compared the results of athletes from schools in the Christchurch area, in terms of their final placing in the event, with the results of athletes from other areas, both before and after the loss of the stadium, and for both theoretically affected events and theoretically unaffected events. In total, our data has 9787 monitored performances over the six years of competition that encompass our data set.

The data set captures the outcome of each individual athlete in each event in each year of the six years of analysis. In particular, we have noted in the data when athletes are from a school located in Christchurch, when they are from a school outside of but close to Christchurch, and when they are from schools located elsewhere. However it makes no significant difference to the results whether the schools that are close to but outside of Christchurch are included with the Christchurch set or with the non-Christchurch set. Given that, in the results reported here these schools are included in the set of schools that are not in Christchurch. We have also partitioned the events into two mutually exclusive sets depending on whether they are “track relevant” or “track irrelevant”. The categorization of the different events is given in Table 1. The “track relevant” events are those for which the availability of an all-weather surface for training and preparations is important, while for “track irrelevant” events either the availability of an all-weather running surface is not really needed at all for training (long

⁷ When the replacement facility in Christchurch was set up, it included new shot-put and discus circles, and an all-weather surface for the long-jump and high-jump runways. Thus those particular events suffered no real detriment in available facilities with the loss of the stadium, outside of any use that athletes in those events had for the running track in their training (e.g. sprint training is important to long-jumpers).

⁸ Of course, there are many schools in the country which do not have (and have never had) easy access to an all-weather surface. Most of them are schools in rural environments. Going from north to south through the country, there are several all-weather tracks in Auckland, one in Hamilton, one in Tauranga, one in New Plymouth, one in Masterton, one in Wanganui, one in Wellington, one in Nelson, one in Timaru, one in Dunedin, and one in Invercargill. However, Christchurch is the only place that has suffered the exogenous shock of having had such a track, and then having lost it.

distance running, race walks), or the substitute venue at Rawhiti filled the needs of athletes (jumpers and throwers).

Table 1: Categorisation of Events

Track relevant (TR)	Track not-relevant (TNR)
100m, 200m, 400m, 800m,	1500m, 3000m, steeplechase
80/100/110m hurdles	Long jump, high jump, pole vault
300m hurdles	Triple jump
4x100m relay	Shot put, discus, hammer throw
4x400m relay	Javelin

3. Analysis

In this section we provide an analysis of the data set of high school athletics performances by Christchurch based athletes over the period in question. Our objective is to test the hypothesis that the loss of the all-weather track has led to a deterioration in the performance of Christchurch based athletes when compared to their performances before the loss of the track, and when compared to the performances of Christchurch based athletes in non-track relevant events.

3.1 A performance metric for Christchurch-based athletes

In order to see if local Christchurch athletes have performed better or worse as a result of the loss of the QEII stadium, we need a metric that measures how well Christchurch athletes did for each event. This is problematic as there are several factors to take into account. Above all, in different events and in different years the numbers of Christchurch athletes, and the total number of competitors is typically different.

The relevant variable for our analysis is the final “rank” of an athlete in an event, which we denote by r . In events with a single competition without qualifying rounds and n competing students, the winner is given a rank of 1, the second-place getter a rank of 2, etc. and the last place getter a rank of n . When multiple students finish tied, they are each given the average ranking for the range they are in – for example, a tied group of t students are each given a ranking of $s + (t + 1)/2$ if there are s students who finished ahead of the group.

In events with preliminary rounds our raw data consists of multiple lines for each athlete-event-year. This is collapsed into a single line by giving the athletes a lexicographic ranking, with the priority given to athletes who advance to the furthest level (so, for example, all athletes who reach the final are ranked ahead of all athletes who make the semi-finals but not the final), and then ranking within a level is made by their relative performance (time or distance) within that level.

Letting r_i be the value of rank for athlete i in a given event-year in which there were n competitors, that athlete’s “percentile” is coded as $R_i = (n - r_i)/n$, giving a value of $(n - 1)/n$ for the highest-ranked athlete in each event-year (i.e. the winner), and 0 for the lowest ranked student (the athlete in the last place), and all others spaced evenly between. The metric R_i has several interesting and appropriate features. First, the lowest ranked athlete, i.e. the one who comes in last, gets the same credit in this metric as if he/she had not competed at all. Second, the metric is monotone decreasing in r_i , that is,

competitors who finish lower down the competition order get a lower percentile value. Third, for all ranks $r_i < n$, the metric is monotone increasing in n , indicating that finishing in a given place (except for last) in a competition is more highly valued the more competitors were present in the competition.

If there are c athletes from Christchurch in the event, then we will get a percentile ranking for each, that is, a vector $R(c) = (R_1, R_2, \dots, R_c)$. We then use as our metric for the over-all performance of the cohort the average of the individual percentile scores; $P = (\sum_{i=1}^c R_i) / c$. Again, some interesting features should be noted. First, since P is the average of a series of numbers all of which are valued between 0 and 1, it happens that $0 \leq P < 1$, with $P = 0$ being achievable only if either there were no athletes in the cohort, or if all of the cohort's athletes finished tied for last place (of course, there could have been a single athlete who finished last alone). Second, since P is an average value, it should not be affected by an increase in the number of members of the objective cohort if there was no increase in their actual abilities (as reflected by their individual ranks). For example, imagine that a student were added to the cohort in an event in which there were no previous cohort members, and that the new student were to finish in the rank that generated exactly the average value of the cohort's original P , then the value of P would not change.

3.2 Participation statistics

The following two figures show the numbers of participating athletes for each category of event.

Figure 1: Numbers of athletes from Christchurch schools

Figure 2: Total number of athletes

Three features are notable in Figures 1 and 2. First, the participation of athletes from Christchurch was significantly negatively affected in 2010, when the first earthquake occurred (only about 2½ months before the championships), but aside from that year, Christchurch participation has shown continual increases year-on-year. Above all, there does not seem to have been any effect on Christchurch participation from the loss of the track, which would have shown up in 2011. Second, the level of participation by all athletes has been relatively constant over time. And third, in terms of the numbers of competing athletes, our classifications of events into the categories “track relevant” (TR) and “track not relevant” (TNR) give very evenly matched categories. That said, however, for the Christchurch cohort, in all years slightly more athletes competed in TNR events than in TR events.

3.3 Percentile summary statistics

Table 2 gives the average percentiles of Christchurch athletes in the different categories of event, for each of the years monitored. This information is also presented graphically in Figure 3. Recall that the loss of the track occurred in 2011.

Table 2: Average percentiles of Christchurch athletes

	2008	2009	2010	2011	2012	2013
ALL	0.480664	0.462208	0.45008	0.449178	0.492292	0.476653
TR	0.526642	0.529326	0.533482	0.506235	0.498078	0.461375
TNR	0.445297	0.410579	0.385925	0.405288	0.487841	0.488405

Figure 3: Average percentiles of Christchurch athletes

In Table 3 we show the change in the average percentile value for the Christchurch cohort for the periods of both with and without a track, along with the percent change in those average values.

Table 3: Effect of loss of track on average percentiles of Christchurch athletes

	track	no track	%change
ALL	0.464318	0.472708	1.806943
TR	0.529817	0.488563	-7.78649
TNR	0.413934	0.460511	11.25246

There was a substantial fall in the performance of Christchurch athletes in track-relevant events following the 2011 loss of the track, and a substantial improvement in their performance in track-irrelevant events. Overall, there was a slight improvement with the loss of the track, which is driven by the fact that the gain in track-irrelevant events is larger than the loss in track-relevant events.

Finally, we also monitored the effect upon what one would assume to be the most track-relevant events – the 400m runs and the 300m hurdles. These events are extremely track-relevant in terms of preparation. The sequence of average percentile values is represented in Figure 4. The change in the average value for the 3-year period 2008-10 compared to the average over 2011-13 is a decrease of 14.15%. While the event seems to be in gradual decline over the entire 6-year period, the change over the first 3 years is insignificant in comparison to the change at the year of the loss of the track, and the change in the final year (2013).

Figure 4: Average percentile of Christchurch athletes in 400m and 300m hurdles races

3.4 Regressions

Regressions were carried out on the entire data ($N=414$), and on 3 sub-samples of the data – the TR events ($N=180$), the TNR events ($N=234$), and the 400m and 300m hurdles events ($N=36$). In the regressions, the average value of the Christchurch athletes' percentile is regressed against a series of dummy variables. SI is a dummy that captures whether the championship event was held in the South Island of New Zealand ($SI=1$) or in the North Island ($SI=0$), TRACK captures the existence of a track ($TRACK=1$) or not ($TRACK=0$), and TYPE captures whether the event is TR ($TYPE=1$) or TNR ($TYPE=0$). The coefficients of the regressions (with p-values in parentheses) are given in Table 4.

Table 4: Regression coefficients and p-values

	All data	TR events	NTR events	400m & 300mh
Intercept	0.429 (0.00)	0.528 (0.00)	0.408 (0.00)	0.586 (0.00)
SI	0.013 (0.54)	0.007 (0.83)	0.018 (0.54)	0.012 (0.82)
TRACK	0.008 (0.68)	-0.041 (0.16)	0.047 (0.10)	-0.083 (0.11)
TYPE	0.072 (0.00)			

From the regressions, we can see immediately the following:

- The intercept term is always very significant, and it is higher the more track-related are the events concerned.
- The location of the championship (South Island or not) is not significant in any regression.
- The existence of a track has a positive effect for TR events and a negative effect for TNR events. For the TR events, the coefficient is only mildly significant, and it is somewhat more significant for TNR events, and for the 400m/300m hurdles events.
- In the regression over all data, event type is very significant, indicating that the Christchurch cohort performed differently in TR events as compared to TNR events.

3.5 Some pertinent queries

a) Are we picking up a linear time trend?

By aggregating the three years with a track and the three years without a track into single categories, we are assuming that the underlying conditions were stable within each of the two periods with a structural break between them. If, however, there was a general trend in which Christchurch's relative performance in track-relevant events was declining slowly over time, our method would falsely pick this up as an event related to the loss of the track.

The effect of the loss of the track upon the two different categories of events can be shown very clearly if one looks at the difference between the average track-relevant percentiles of the Christchurch cohort of athletes to their average track-not-relevant percentiles. In terms of Figure 3, this is the red line less the green line. This difference is shown in Figure 5. There is clearly a marked change exactly at the year in which the track was removed. For the first 3 years of data (when there was a track), the Christchurch cohort was improving year-on-year in TR events, and deteriorating year-on-year in TNR events. Both trends were reversed as soon as the track was lost.⁹

Figure 5: The difference between the average TR percentile and the average TNR percentile of Christchurch athletes

c) Is average percentile a poor measure of relative performance?

The average percentile is a single measure of the overall performance of Christchurch athletes, but might hide something going on in the tails of the distribution. The graphs below (Figures 6 and 7) show the average percentiles for the TR and the TNR categories, for all event-years within each category, ordered from smallest to largest, for both the scenario with a track and without.

⁹ Performing a Chow test on this 6 year time series, with an assumed structural break after the first 3 years of data, gives a Chow statistic of 20.5, confirming that the loss of the track indeed constituted a structural break in the data.

Figure 6: Ordered percentiles when a track was present

Figure 7: Ordered percentiles when a track was not present

What is clear from these graphs is that the decline in performance in track-relevant events was consistent across the majority of the distribution (for all but those who finished last when there was a track, and for the very top event-years where the two curves merge), whereas the effect in track-non-relevant events is consistent across the distribution with again the exception of the very top event-years. In general, the effects are consistent across the distributions, not just at the means as we saw in the earlier tables.

d) Is it a selection issue with athletes changing event-type or region?

We have no way of telling if athletes chose their event or region as a result of the earthquake prior to their entering the database, but we can observe athletes who change event or region within the period of our data.

For event changes, there are many athletes who start out competing in more than one event, but later appear in only the one, as a result of specialisation. We therefore looked at every athlete who initially participated *only* in track-relevant or track-not-relevant events and then in 2011 or later changed to participating *only* in the other category. That is, we don't consider athletes who completed a change prior to 2011, but because it might take time for some athletes to adjust to the lack of facilities, but we do consider any athlete who changed category of event at any time in or after 2011.

There were only three Christchurch athletes who switched from track-relevant to track-not-relevant events in or after 2011, and these were balanced by three athletes who made the reverse change. In the rest of New Zealand, the numbers were 13 and 19, respectively. Interestingly, the Christchurch athletes switching out of track-relevant events were stronger (percentile in their best event being 0.81) than those switching in (best percentile of 0.61), while the reverse is the case for the non-Christchurch athletes (0.50 versus 0.72), suggesting that there might have been a causal effect on the choice of event for those 3 elite Christchurch athletes, but the numbers are too small to be driving factor behind our results.

For people switching into or out of Christchurch, the database includes two athletes who moved into Christchurch after the earthquake, and none who moved out. Again, these numbers are obviously far too small to explain our results.

e) Are the results statistically significant?

The regression analysis alone, for the two different categories of events, shows that the improvement in the track non-relevant events after the track was lost is significant at the 10% level. The fall-off in performance in the most track-relevant events (400m and 300m hurdles) is almost as significant at 11%, while the general fall-off in track-relevant events is mildly significant at 16%. However, when looked at from a difference in difference perspective (Figure 5), the Chow test for a structural break at exactly 2011 is 20.5, which is very significant. We can therefore state that the data shows very strong evidence that the loss of the stadium has caused a significant turn-around in the trend in performance of Christchurch based athletes, who pre-2011 were trending year-on-year towards better track-relevant performances relative to track-non-relevant events, and who post-2011 reversed this trend.

4. Conclusions

This paper has considered whether or not the loss of the QEII athletics stadium has resulted in a deterioration in the performance of athletes living in the local affected area. The data used is from the New Zealand National Secondary Schools Athletics Championships, for the three years immediately prior to the loss of the stadium (in 2011), and for the three years immediately after the loss. The data indicates that there was a mildly significant deterioration in the performance of Christchurch based athletes in track-related events, with a stronger significant deterioration in the most track-relevant events. However, the loss of the track appears to have caused a countervailing significant improvement in the performance of Christchurch based athletes in events that are not track dependent. The difference in difference approach shows that the trend change in track relevant events relative to track non-relevant events is very significantly tied to the structural change of 2011.

This study suggests that by not having an all-weather track locally for the purposes of training and race preparation, Christchurch based athletes have been disadvantaged relative to athletes in the rest of the country, in as much as performance in track related events is concerned. This is a result that is in accordance with general expectation, even though there does exist some literature that provides arguments for an opposite effect to exist. If such an opposite effect has existed, then the negative effect is all the larger. Perhaps of greater concern is the fact that the trends that came into play with the loss of the track have continued (at least over the next three years), so the loss of the track does not appear to have caused a shift to a lower but stable level of performance, rather the continual deterioration in track-related event performance is ongoing.

The fact that the opposite trends have occurred in the track-non-related events is more difficult to explain, but it might well indicate that athletes coming into the sport of athletics since the loss of the stadium are more likely to take-up events that do not rely upon a track. It is also true that after the loss of the track, significant improvements in facilities for track-non-related events were installed around Christchurch (easily accessible all-weather long-jump run-ups, new shot-put and discus circles, etc.), which may have had the effect of attracting new athletes to those events.

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Appendix: List of schools in the Christchurch area included in the study

Avonside Girls' High School
Burnside High School
Cashmere High School
Catholic Cathedral College
Christ's College
Christchurch Boys High School
Christchurch Girls High School
Hagley Community College
Hornby High School
Linwood College
Marian College
Middleton Grange School
Papanui High School
Rangi Ruru Girls' School
Riccarton High School
Shirley Boys' High School
St Andrew's College
St Bede's College
St Margaret's College
St Thomas Of Canterbury College
Villa Maria College

There are a number of Christchurch schools not in this list (e.g. Aranui High School). This simply indicates that they did not have any athletes competing in the National Championships in any of the six years of our data.