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The Relative Age Effect in Elite Dutch Track & Field

The Role of Performance Based Selection Systems

Master thesis Economics

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Abstract

The occurrence of relative age effects (RAEs) has been documented in many domains. This study will show that it is also present in elite Dutch track & field. This will be done by using the official rankings of the KNAU (Koninklijke Nederlandse Atletiek Unie; in English: Royal Dutch Track & Field Federation) of the seasons 2000-2010. The RAE is generally found to exist for most of the disciplines and within all seasons. However, it tends to decline when athletes become older, indicating that physical development, combined with the cut-off date, is a factor that contributes to the occurrence of the RAE. Thus, the performance based selection system is not working properly. By using the objective performances that track & field provides, it will be shown that there are indeed performance differences between early and late born peers, which are not taken into account by the selection system. Especially at early ages these differences can become relatively large. The solution would be to improve the selection system by the incorporation of the estimated differences. In addition, this study will show that some clear differences exist between males and females, which become especially evident during adolescence.

1. Introduction

In a perfect world, we would expect the most skilled, talented or driven people to be the most successful ones. In an imperfect world, however, such as the one we live in, we observe that success is dependent on other factors as well. Malcom Gladwell wrote a bestselling book about this topic titled *'Outliers; the story of success'.* Amongst others, Gladwell discusses the role of opportunities, in which date of birth is a factor for success. At first this might seem a bit strange, since birthdates are exogenous to people and, therefore, unrelated to personal success. However, it has been shown that some people have a higher probability of being selected for, for example, sports teams, simply because they are born closely to a specific cut-off date that separates age categories. Within the literature a term commonly used in relation to this phenomenon, is the relative age effect (RAE).

The first to research this phenomenon within a sports context were Grondin, Deschaies & Nault (1984) and Barnsley, Thompson & Barnsley (1985). They looked at Canadian ice hockey and found a huge overrepresentation of players born closely after the cut-off date, which was the 1st of January. Following were a multitude of studies, covering a variety of areas varying from school performance and academic achievement (e.g., Angrist & Kruger, 1991; Plug, 2001), sports (e.g., Musch & Grondin; 2001) and, last but not least, suicide rates (Thompson, Barnsley & Dyck; 1999). The common feature in all these areas is that the cut-off date determines who is the youngest and who is the oldest within a group. A simple example makes clear that, especially at early ages, the differences can be pretty big. Suppose that the cut-off date for primary school is set on the 1st of January. Now take as an example, two girls. The first turns five years old on the 1st of January, the second turns five years old on the 31st of December of the same calendar year. Then both kids are in the same grade, but exactly differ one year in age. At age four, this difference means that the second child is 25 per cent younger than the first child, a huge gap.

Of course, the relative age gap as used in the example above will decline over time, but the problem is that the younger girl might not get the same opportunities as the older one gets when growing up. The younger one might very well be more talented in a given discipline, but since she has less possibilities to develop, because she was not selected in the first place (e.g. for extra, more challenging math classes), her talent will be lost. In statistical terms this would be a type I error.[1] On the other hand, the older one will be seen as successful, but might in fact be only a second best

[1] Although it is in general hard to find 'type I' errors in selection systems, since the ones not selected will not be known afterwards, a anecdote by René van der Gijp during the television show of Voetbal International of 16 September 2009 might be seen as such an error. He explains that Boudewijn Zenden was not selected by PSV at an age of eleven years old. Eventually, PSV did ask him to play for their youth academy about five years later. Zenden has 54 caps for the Dutch national soccer team. We know this because PSV gave him a second chance, something people rarely get.

solution, which would be a type II error in statistical terms.[2] The RAE, therefore, has both an individual as well as a social implication. On a micro level, the lack of opportunities to develop might result in personal dissatisfaction (e.g., Thomson, Barnsley, & Battle; 2001 document lower self-esteem for late born children), while on a macro level, the second best solution is, by definition, not optimal and evidence exists that a good allocation of talent fosters economic growth (Murphy, Shleifer & Vishny; 1991).

Above it has been assumed that the older child is given more opportunities and will be selected, while the younger girl is given less opportunities, since she was not selected. However, no attention was paid to why exactly the older one was selected in the first place. This mainly has to do with the way selection systems are working. Time and budget constraints mean that not everyone can be offered exactly the same, so opportunities should be given by way of selection, e.g. for a better squad, extra training in sports or for extra and more challenging math classes in school[3]. Ideally, then, you want to select, say an athlete, who has the potential to win the Olympic Games and give this person extra attention already at an early age. However, the difficulty is to determine potential, especially over a long time span. Therefore, selection is often based on current performances. Since physical and mental development is rather equal between peers of the same gender and, thus, start around the same age, the current performances might simply reflect a gap in development (Vincent & Glamser; 2006).[4] Being relatively older means being more developed than your younger peers, which means a physical advantage and a better ability to concentrate. If, then, more development results in better current performances, as is very likely in, for example, ice hockey (Sherar, Baxter-Jones, Faulkner & Russell; 2007), the RAE in relation to the selection of the age advantaged can be explained.

The focus on current performances during selection procedures thus results in an RAE. As already mentioned, selecting potential would be the best solution to overcome this problem. Although Williams & Reilly (2000) argue that the expertise of professional coaches should not be underestimated, it is a difficult task. Therefore, some researchers have proposed to measure the development of performances (e.g. Gagné; 2004). In this way, progress is leading in the selection procedure. The problem is, however, that it is costly to track the development of all individuals, especially in team sports, where the relatively younger athletes have to compete against relatively

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[2] These examples are easier to find. It could be argued that author himself belongs to this group, since he was selected for the youth academy of the professional soccer club NAC Breda until his 18th birth date, but never played for the first team.

[3] A difference between sports and school is that someone can easily decide to drop out of sports, but, at least in the Netherlands, it is mandatory to go to school until the age of 16. This distinction will be discussed in section 7.

[4] The differences in development between genders are especially visible during puberty. The gender differences will be discussed in more detail further on in the text.

older ones in the same competition. Furthermore, it is often hard to objectively measure performances and thus progression. If this is possible, current performances can be compared between people, despite any relative age gap. In school achievements, standardized test scores could be used. Unfortunately in sport, such data is often not available. One of the exceptions, however, is track & field, which will be the subject of this study[5].

Most previous studies of the RAE in sports have focused on team sports. By investigation of track & field, which is historically the most important sport of the Olympic Games, we will see that an RAE also exists in individual sports[6]. Furthermore, most studies only used male athletes, mainly because of limited data on female athletes. Since track & field is practiced by both males and females, and since data is available in more or less equal amounts, this study will be a valuable contribution in that respect as well. Finally, as already mentioned in the previous paragraph, track & field provides an objective measurement of performance. This will be used to determine if an RAE coincides with a performance difference between early and late born peers. The estimations of these differences can then be used in the comparison of performances those relative differently aged individuals. Again the differences between genders will be discussed.

This thesis will proceed as follows. Section two will provide insight into some literature on talent selection, identification and development; section three will review related literature on RAEs in sports; section four will provide some background information on track & field and in particular how the Dutch system is organized; section five will describe the data and methodology that will be used; section six will present the results, which will be split in two separate parts, the RAE and performance differences; section seven will present a discussion, in which multiple aspects will be reviewed; and finally section eight will conclude.

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[5] A detailed description of track & field, with some background information of the Dutch system, will be given in section 4.

[6] The informed reader will note that there are some disciplines which have to be done by a team, like relay races. These disciplines are however, left out of the analysis, since it is not possible to link a performance to a specific date of birth.

2. Talent selection, identification and development

Since it is an essential element in the development of expertise, this section will briefly review some important studies that contributed to the debate about talent and its selection, identification and development. A central theme within this debate is the role played by nature and by nurture. An exhaustive overview would be beyond the scope of this thesis, therefore only some main conclusions will be reviewed. For a comprehensive discussion, I would like to refer to an academic review on talent identification and development, by Abbot, Collins, Martindale & Sowerby (2002).

More than a century ago, Francis Galton (1874) was one of the first to discuss the role of nature and nurture in relation to talent. He argued that a strong relation exists between achievement domains within families, which made him conclude that inherited factors are responsible for success (Galton; 1869). For this reason he, thus, advocates that nature is more important than nurture in explaining talent. The implication of this thought is that someone who is not identified as having innate talent in a particular domain, will never get the support to achieve expert performances (Howe, Davidson & Sloboda; 1998). If nurture only plays a minor role, this would not be much of a problem. The only thing that needs to be done is predicting innate talent at early ages, which could be done by looking at family members.

However, in their seminal paper, Ericsson, Krampe & Tesch-Römer (1993) document that environmental factors are far more important than was generally thought before. They introduced the concept of deliberate practice, which is effortful practice that is not inherently enjoyable, but improves results and is found to be relevant for becoming an expert within a particular domain. Ericsson *et al.* (1993) use violists and pianists to show that the best performers are the ones that conducted more deliberate practice compared to less performing peers. It takes about 10,000 hours of practice to become an expert, which someone typically reaches after 10 years (Ericsson *et al.*; 1993).[7] Given the assumption of monotonic benefits and since the starting ages of peers did not differ much, the amount of deliberate practice is what separates 'good' from 'best' performances. It is important, in this respect, that parents, teachers and coaches give a child the opportunity to train and develop: i.e. the environment should be supportive. This will only be the case, however, if there are early signs that the child could become an expert. Early signs of expertise could, of course, be the result of innate talent. But Ericsson *et al.* (1993) reject this possibility, since most aspects that might indicate a promising star, are learned through early experiences (e.g., listening to a lot of music).

[7] This coincides with the '10 year rule', that was introduced by Simon & Chase (1973) in chess and is found to exist in other domains as well, such as: middle distance running (Young & Salmela; 2002), wrestling (Hodges & Starkes; 1996), figure skating (Starkes, Deakin, Allard, Hodges & Hayes, 1996; and Helsen, Starkes & Hodges; 1998), field hockey (Helsen *et al.*; 1998), mathematics (Gustin; 1985), swimming (Kalinowski; 1985) and tennis (Monsaas, 1985).

Perceived innate talent is then in fact the result of environmental factors, which in turn are a precondition to accumulate the necessary amount of deliberate practice to become an expert performer (Ericsson *et al*; 1993).[8]

In their literature review, Howe *et al.* (1998) also questioned the role of innate talent and concluded that this is not a convincing explanation of expertise. 'It is important to keep in mind that early ability is not evidence of talent unless it emerges in the absence of opportunities to learn' (Howe *et al.*; 1998, p. 403). They furthermore state that innate talent is often inferred instead of observed and is a simple way of explaining differences in performances without the necessity to account for all individual differences (e.g., differences in motivation, strength and concentration). In line with the concept of deliberate practice from Ericsson *et al.* (1993), Howe *et al.* (1998) argue that most early signs of expertise are the result of experiences and opportunities to learn, while a large amount of practice is necessary to become an expert in adulthood.[9]

The theory of deliberate practice has also been used within sports contexts (e.g. Young & Salmela, 2002 in middle distance running; Starkes *et al.*, 1996 in sport in general; Hodges & Starkes, 1996 in wrestling; Helsen *et al.*, 1998 in soccer and field hockey; Helsen, Hodges, Van Winckel & Starkes, 2000 in soccer; Ward, Hodges, Starkes & Williams, 2007 in soccer). Although the results turned out to be more or less the same as found for musicians (Ericsson *et al.*; 1993), a difference was that the relevant practice for sport performances (in particular team practice) was enjoyed by the participants. Furthermore, Hodges & Starkes (1996) have also argued that a distinction should be made between physical and mental effort, since not all practice requires both or in equal amounts. It has been shown that a separate dimension measuring concentration is relevant within the framework of deliberate practice (Hodges & Starkes, 1996; Helsen *et al.*, 1998). Cumming & Hall (2002) used this 'mental' dimension, instead of physical effort, to study the effect of deliberate imagery practice within a wide range of different sports. However, their results did not comply with the original theory of deliberate practice, nor with the sports specific framework, since they found a positive relation between relevance and enjoyment, but not between concentration and enjoyment.[10]

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[8] Although it might seem that the deliberate practice view means that everyone can become a star in every domain, Ericsson *et al.* (1993) acknowledge the importance of some innate influences (e.g. height) and that not all people have the same maximum capabilities (e.g. in basketball).

[9] Although a comprehensive discussion of how exactly this practice results in expertise would be beyond the scope of this text, Sitskoon (2006) provides an interesting explanation. In her book 'Het maakbare brein; Gebruik je hersenen en word wie je wilt zijn' [The makeable brain: Use your brain and become who you want to be] she describes that one's brain can evolve, within certain bounds, by one's behavior and his interaction with the environment. The capacity of the brain, thus, evolves, which means the person will change too. Sitskoon (2006), thus concludes that practice results in expertise by way of a changing brain.

[10] Ericsson *et al.* (1993) predict a positive relation between 'relevance' and 'concentration', while a negative between 'relevance' and 'enjoyment' and 'concentration' and 'enjoyment'. The sports-specific framework as

Of particular interest to this study is an article by Helsen *et al.* (2000) which examines the validity of deliberate practice for British youth soccer in light of a relative age effect. Although their conclusion is that domain-specific knowledge and practice (i.e. deliberate practice) is important for elite performances, coaches should be more aware of the fact that they are working with a biased selection towards the physically advantaged children (i.e. the relative older ones). Providing equal opportunities would mean that no 'talents' (the ones that have a higher potential than others) are missing the necessary practice to reach expert levels (Helsen *et al.*; 2000), while at the same time prevents a bad investment of scarce resources (Abbott & Collins; 2004).

Until now, we saw evidence that the nurture-based concept of deliberate practice provides some appealing and useful insights. However, in the previous paragraph, some literature has been discussed that raised critiques concerning the equal opportunities for participants within a domain. Other doubts about the validity were raised by Simonton (1999). Although he states that 'it is extremely likely that environmental factors, including deliberate practice, account for far more variance in performance than does innate capacity in every salient talent domain' (Simonton; 1999, p. 454), he developed a model in which talent is multidimensional, multiplicative and dynamic (rather than unidimensional, additive and static) which gives talent a more prominent role in the development of expertise. The model consists of two stages. Stage one is the emergenic part, which considers the differences between individuals in their level of different components (e.g., speed and motivation). The components are not domain-specific (e.g., speed and motivation are useful in multiple sports) and by multiplying the relevant ones, where relevance is measured by some weight factor, an individual's potential talent within a particular domain can be inferred.[11] This way of modeling implies that talent is domain-specific, since a zero score on a relevant component makes someone 'untalented', which also implies that the distribution of talent is heavily skewed to the right (i.e. a lot of 'untalented' people). Given that the number of relevant components might differ, the complexity of talent domains will differ too. Furthermore, the model provides for the heterogeneity in component profiles within a specific domain, which makes the predictability of talent harder. Finally, since this part of the model is based on an emergenic[12] relation, it predicts low familial inheritability (Simonton; 1999). Part two of the model, the epigenetic[13] part, describes how talent

proposed by Hodges & Starkes (1996) and Helsen *et al.* (1998) predicts a positive relation between all three dimensions.

[11] Formally this is: $P_i = \prod_{j=1}^{k} C_{ij}^{W_j}$ in which P_i is the potential talent for individual i, C_{ij} the ith individual's score on component j and w_{ij} is the weight given to the jth component for individual i, with $(w_{ij} > 0)$ (Simonton; 1999).

[12] Emergenic means that a trait stems from a specific combination of several interacting genes (not simply from adding independent genes).

[13] Epigenetic means the development of traits as a result of a specific gene structure.

develops. It models talent as being time-dependent and is thus dynamic.[14] The moment at which development takes place (and ends) is both person- and component-specific. An interesting feature of this type of development is that it allows for early bloomers and late bloomers. The model's prediction is that there will only be a few early bloomers, since those should have high scores on all relevant components, while many late bloomers will occur because of a lot of 'zero scores' early on in the development phase.[15] The model also takes account of the fact that talent is not necessarily visible at early ages and it allows for the loss of talent, in relative terms (different development rates for individuals at a given moment in time) as well as absolute terms (e.g., an injury). Furthermore, since components are time dependent, an individual's optimal domain might change. An example might be someone who seems to be a talented baseball player, but at age 16 turns out to be better in American Football. Although Simonton's model (1999) does not provide practical policy implications, it gave new insight into the role of innate factors and made researchers think of talent in a multidimensional, multiplicative and dynamic way.

Williams & Reilly (2000) did this and reviewed the literature on talent identification and development in male soccer. Although they specifically look at soccer, their findings seem to hold for other sports as well. Nonetheless, they note that their conclusions cannot be generalized to females. Williams & Reilly (2000) start with setting out four stages of talent identification and development. The first stage is 'detection' (the discovery of potential performers, not yet actively involved in the given sport), which precedes 'identification' (recognizing potential elite performers). After identification, the potential talents enter the 'development' stage. Here they are placed in an environment which allows them to realize their potential. The final stage, 'selection', describes this as an ongoing process, in which less participants will enter further development at more demanding levels. Although this ongoing selection might seem to correspond with the dynamic nature of talent as proposed by (Simonton; 1999), Williams & Reilly (2000) state that, given the increased competition between clubs, talent should be identified as early as possible, so as to focus expenditures on the most promising stars and, thus, neglect the 'late bloomers'. However, in line with Simonton (1999), Williams & Reilly (2000) argue that multiple dimensions should be considered that might interact. Besides physical attributes, one should look at physiological, psychological and sociological aspects in talent identification and development. With respect to the physical aspects,

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[14] Formally the equation becomes: $P_i(t) = \prod_{j=1}^{k} C_{ij}(t)^{Wj}$, in which t represents time and the other characters are identical to those in footnote 11.

[15] Note that someone is seen as untalented if he or she has a 'zero score' on any of the relevant components. Given the dynamic nature of the model, a 'zero score' might change into a positive score after some period of time. In the early stage of development, however, there will still be a lot of 'zero scores' on any of the relevant components, which implies the person is seen as untalented. When development starts for all relevant components, the person might become a late bloomer. However, he or she will stay untalented if development does not result in positive scores on all relevant components.

they note that this should not have an overwhelmingly large influence, since it might result in a skewed birth-date distribution and thus a loss of potential talent (Williams & Reilly; 2000).

The psychological aspect is more closely considered by Abbott & Collins (2004). Although they agree with, for example, Simonton (1999) that multiple determinants of performance exist and talent identification and development is a dynamic process, they argue that psychology is the only dimension that separates the ones that 'become' successful and the ones that 'maintain' to be so (Abbott & Collins; 2004). In their view (in line with Ericsson *et al.*; 1993), progression will occur if participants are motivated to invest in practice, while at the same time use strategies such as goal-setting and imagery (i.e. self-regulatory learning strategies) to optimize development given the opportunities that are provided by the environment. The path to excellence is complex and requires a constant adjustment, initiated by the self-regulatory strategies, of the optimal conditions (Abbott & Collins; 2004). In contrast to Williams & Reilly (2000), Abbott & Collins (2004) state that early identification (as happens with scouting in soccer) should only play a minor role. Instead, the provision of opportunities to develop is more important. Psychological factors such as motivation and self-regulatory learning strategies will then guide progression (Abbott & Collins; 2004).

The relation between self-regulation and motivation on the one hand and performance levels on the other hand was tested by Toering, Elferink-Gemser, Jordet & Visscher (2009). They used data of youth male soccer players aged 11-17 years from the Netherlands. The sample was split in elite players (playing in the youth academy of a professional soccer club) and non-elite players (playing for a non-professional soccer club) and the level self-regulatory strategies was measured by way of questionnaires. In line with theory, the result showed a positive relation between performance level and effort (i.e. motivation) and (self)reflection. This result, however, does not indicate that participants should have much self-regulation before being selected, since it might well be developed afterwards (Toering *et al.*; 2009). The only conclusion that can be based on this observation is that effort and (self)reflection are a prerequisite for expertise. Another study (Toering, Elferink-Gemser, Jordet, Pepping & Visscher; 2011) also looked at the role of self-regulation and performance levels, but controlled for any RAE as a potential moderator variable. This was done, since relative age might affect the relation between self-regulation and performance through its influence on maturation, experience and performance level. A sample of Dutch players of age 12-17 was used. Elite players are now those selected for the representative teams (national and district) of the KNVB[16,17]. Non-elite players consist of those in a youth division of a professional football club, but not selected by the KNVB. For both groups a RAE was found, while stronger in the elite group. Also, again a positive

[16] Koninklijke Nederlandse Voetbal Bond.

[17] The KNVB divides the Netherlands into six districts, representing a more or less equal share of the population.

relation was found between self-regulation and performance level. Interestingly, this relation was not affected by relative age, which made the authors conclude that self-regulatory strategies might be a valuable measure in talent identification, instead of the often used discrete and physical measures (Toering *et al.*; 2011).

Vaeyens, Lenoir, Williams & Philippaerts (2008) lead us to conclude, however, that talent identification and development programs in sports are not yet able to incorporate all important elements and to overcome all identified problems. They start with an elaboration of the problems with the current (cross-sectional) designs. Four main issues are discussed. One of them is the maturity-related problems that cause a skewed birth-date distribution (i.e. a RAE). The others are the focus on current performances, the lack of acknowledging the dynamic nature of talent and its development and the focus on only a limited number variables (Vaeyens *el al.*; 2008). In conclusion, the authors state that: 'there is a need for a conceptual framework for TID [talent identification] and TDE [talent development] that rests on the distinction between potential and performance, while acknowledging all potential determinants of talent' (Vaeyens *et al.*; 2008, p. 706). In light of this statement, they continue with a discussion of the Differentiated Model of Giftedness and Talent (DMGT) as formulated by Gagné (2004). This model makes a distinction between 'gifts' (i.e. natural abilities)[18] and 'talent' (i.e. expertise), with talent emerging through a talent development process.[19] The ease and speed with which this takes place determines the level of giftedness, in which easier and faster signifies more giftedness (Gagné, 2004; Gagné 2009). Three types of catalysts influence the development process: intrapersonal, environmental and chance (Gangné; 2004). In an updated version, 'chance' was removed as a catalyst and entered as a background influence, mainly on the environmental factors. The influence of these environmental factors on the developmental process, in turn, changed from a direct influence to a mainly indirect way through intrapersonal aspects (Gagné; 2009). Despite these changes, in the DMGT the transformation of 'gifts' into 'talent' takes place by numerous causal interactions between all the elements of the model. Furthermore, since these elements differ for all individuals, the model does not predict a unique path towards excellence (Gangé; 2004).

Although the DMGT was initially developed in the domain of education (Gagné; 1993), it has been acknowledged as a useful developmental theory within a sports context (Gagné, 2004; Vaeyens *et al.*, 2008; Gagné 2009). The statement by Vaeyens *et al.* (2008, p.706) as cited above asked for a distinction between potential and performance. The DMGT provides such a distinction, since

[18] It is important to note that these natural abilities are not necessarily innate, since they might develop over time.

[19] In the model, someone is stemmed 'gifted' or 'talented' in a particular domain if she belongs to the top 10 percent. Gagné (2004) discusses in detail this threshold level. However, it would be beyond the scope of this text to reproduce that discussion over here.

potential is recognized by the rate of learning (Vaeyens *et al.*; 2008). Furthermore, the model is appealing since: 'It recognizes the potential respective influences of nature and nurture and takes into account the dynamic and multidimensional features of sport talent' (Vaeyens *et al.*; 2008, p. 707). In doing so, the DMGT might well overcome the problems that the other, cross-sectional designs of talent identification and development models face. However, the model might need to be refined given a specific question. Recently, Gagné (2010) did this when considering the role of motivation within the DMGT. As part of the intrapersonal catalyst, an in depth analysis of this part of the model showed that motivation plays a large role in the development process, as is also found by other researchers (e.g., Ericsson *et al.*, 1993; Abbott & Collins, 2004).

Summarizing this section, we saw that, historically talent was attributed to innate factors. However, more recently researchers started to question this explanation and looked for other underpinnings of expertise. The nurture-based view, in which (deliberate) practice plays a central role, gained support. In the present, most researchers agree that talent identification and development should be multidimensional and dynamic. Furthermore, they agree that selection should not be based on current performances, but on potential and the development of natural abilities. The DMGT, in which environmental and intrapersonal (e.g. self-regulatory strategies) guide development, provides a useful theoretical framework in this respect. It might resolve the problems of earlier talent identification and development models, of which a skewed birth-date distribution is one. Below we will see, however, that the RAE has been persistent over time.

3. Overview of related literature on the RAE

This section will give an overview of related studies that looked at the RAE. Although the RAE has been studied in many different domains, this section will focus on those studies that address the RAE in sports. In doing so, some potential 'causes' of the RAE and 'remedies' to the RAE that were proposed will be discussed.

As mentioned in the introduction, the first to document the existence of a RAE in sport were Grondin *et al.* (1984) and Barnsley *et al.* (1985). Grondin *et al.* (1984) looked at different competitive levels of Canadian ice hockey and volleyball for players from junior and senior ages and observed a significant overrepresentation of early born players[20] (for volleyball this was only found for the elite levels). Barnsley *et al.* (1985) only looked at elite adolescent and elite senior Canadian ice hockey and found similar results. A follow-up study by Barnsley & Thompson (1988) showed that a RAE was also present within the junior divisions of Canadian ice hockey. Furthermore, they found that this RAE was largest in the top tiers of the ice hockey system. Two conclusions were based on these observations, which may account for the results as found by Barnsley *et al.* (1985). First, given the overrepresentation of early born players, it can be concluded that these will stay active within the sport, while late born participants will drop out. Second, given that the RAE is mainly visible within the top tiers of junior ice hockey, it is likely that the RAE will proceed into senior elite levels, since those age-advantaged participants, playing at young ages for better teams, are provided with the opportunities (e.g. better training and coaching) to fully develop (Barnsley & Thompson; 1988).

Following the example of the studies mentioned above, many researchers have looked at the RAE, covering a wide range of different sports. An overview is presented by Musch & Grondin (2001) and by Cobley, Baker, Wattie & McKenna (2009), who conducted a meta-analysis. The sports that gained most attention are ice hockey (e.g., Grondin *et al.*, 1984; Barnsley *et al.*, 1985; Barnsley & Thompson, 1988; Sherar *et al.* 2007; Nolan & Howell, 2010; Addona & Yates, 2010) and soccer (e.g., Verhulst, 1992; Dudink, 1994; Helsen, Starkes & Van Winckel, 1998; Musch & Hay, 1999; Helsen *et al.*, 2000; Helsen, Starkes & Van Winckel, 2000; Simmons & Paull, 2001; Vaeyens, Philippaerts & Malina, 2005; Helsen, Van Winckel & Williams, 2005; Vincent & Glamser, 2006; Ashworth & Heyndels, 2007; Jiménez & Pain, 2008; Augste & Lames, 2011). Other sports in which a RAE was found are baseball (Thompson, Barnsley & Stebelsky; 1991), swimming (Baxter-Jones, Helms, Maffualli, Baines-Preece & Preece; 1995), tennis (Baxter-Jones *et al.*; 1995) and basketball (Hoare; 2000). A sport in which no RAE was found is gymnastics (Baxter-Jones; 1995 and Baxter-Jones *et al.*; 1995), with a slight overrepresentation of late born athletes.

[20] For convenience, and since cut-off dates might differ between domains, throughout this text, 'early born' means that someone is born just after the cut-off date, while 'late born' means that someone is born just before the cut-off date.

An often used argument for the occurrence of a RAE within sports is the physical advantage that early born players have over their peers (Musch & Grondin, 2001; Cobley *et al.*, 2009). The reasoning is that a physical advantage results in better current performances, especially early in life, which form the basis for talent selection and identification procedures (see also the previous section for a discussion on talent selection and identification methods and models). Although this reasoning seems attractive, the amount of quantitative evidence is rather limited. One of the studies that provides such evidence is Sherar *et al.* (2007), by using maturational data of selected and non-selected participants at Canadian junior ice hockey selection camps. The ones that were selected showed more physical development than those not selected. Also, most of them belonged to the early-born group of players (Sherar *et al.*; 2007).[21] Furthermore, the overrepresentation of late born participants found in sports where physical development is a disadvantage (e.g. Baxter-Jones *et al.*; 1995, who also document late maturation for successful gymnasts) provides evidence of the importance of physical development in relation to a RAE. Other, more indirect, evidence is found by Delorme & Raspaud (2009), who looked at the French shooting sport. Since physical development is of limited importance for shooting (concentration is probably far more important), they hypothesized that a RAE would not exist. This hypothesis was confirmed for all female participants and for male participants aged between 13-20 years, but not for male participants aged between 11-12 year old and adult male participants (adults being aged 20 years old or older). For the young group this might have to do with the fact that parents do not want their young children to be involved in an 'aggressive' sport such as shooting[22], while for adults this might have to do with the fact that early born participants did not become successful in a physical sport (e.g. because they lost their advantage or did not develop as expected) and therefore switched to a non-physical sport (Delmore & Raspuad; 2009). In general, the results show that in a non-physical sport such as shooting, a RAE is absent, or has to be explained by other factors than physical development.

Although it, thus, seems to be the case that physical development plays a role in the occurrence of a RAE, it cannot be the only explanation (Musch & Grondin; 2001). This conclusion is based on the observation that conflicting evidence exists of the skewness of the distribution of birth-dates between age cohorts. If physical development would be the only factor, we would expect a reduction of the intensity of skewness, because the relative age difference compared to actual age decreases over time (Musch & Grondin; 2001). Barnsley & Thompson (1988), Hoare (2000), Helsen *et al.* (2005) and Cobley *et al.* (2009), however, document an increase in intensity from early ages up to adolescence, while, Hoare (2000) and Cobley *et al.* (2009) also find a decrease in intensity for adult

[21] The initial selection of participants was based on self-subscription, which resulted in a physically diversified group that covered the whole age range (14-15 years old).

[22] If parents only allow their children to practice the shooting sport if they have passed their 12th anniversary, this will 'disadvantage' the late born kids.

ages[23]. Cobley *et al.* (2009) discuss three possible explanations for this later finding. The first is the already mentioned diminishing of a physical advantage.[24] Another possibility is that players change their sport when entering adulthood, while a third possibility is that the early born athletes will resign from the sport earlier than their late born peers, e.g. because of an injury as a result of overtraining due to a talent program they have been active in (Cobley *et al.*; 2009).

Although it was not made explicit that the studies that were discussed in the former part focused on male participants, it is important to note that the findings cannot be generalized to females. We already saw that some gender differences exist in the French shooting sport (Delmore & Raspuad; 2009), in which all active members, participating in all different levels, were included. Vincent & Glamser (2006) specifically looked at the differences in RAE between genders for the Olympic youth soccer programs in the US. They did find a RAE for 17 year old male soccer players, but not for their female peers. The authors argue that physical development is not necessarily an advantage for females (in soccer), while early maturing females will probably have more struggles than males with settling their 'traditional feminine role' in sports. It makes them conclude that the difference between genders in RAE can be explained by: 'a complex and dynamic interaction of biological, maturational and socialization issues' (Vincent & Glamser; 2006, p. 412). Although with less focus on the gender differences, Helsen *et al.* (2005) also found smaller RAEs for European elite adolescent female soccer players than for male adolescent soccer players, while Hoare (2000) found similar results for Australian basketball. At younger ages, however, the RAE for females is as profound as for males (Baxter-Jones & Helms; 1994). By investigating the birth-date distribution of female elite British swimmers, gymnasts and tennis players aged 8-16 years old, Baxter-Jones & Helms (1994) found an overrepresentation of early born players in swimming and tennis, but not for gymnastics. Cobley *et al.* (2009) used gender as a moderator variable in their meta-analysis, where they used most of the above mentioned studies, but only found a weak influence of gender. A potential reason might be that only two percent of their sample consisted of females. This leads them to conclude, together with most other researchers, that more studies should look at the RAE in female sports (e.g., Cobley *et al.*, 2009; Musch & Grondin, 2001).

Then, the role of competition can be monitored more closely. In general, two ways are used to proxy for the amount of competition. The first is to look at the playing level (elite vs. non-elite) the second is to look at the difference in popularity (i.e. total number of participants) between sports. The hypothesis that more competition will increase the severity of a RAE is confirmed by some previous research (e.g., Grondin *et al.* (1984) for playing level in Canadian ice-hockey and also the

[23] Barnsley & Thompson (1988) and Helsen *et al.* (2005) did not cover the adult age group.
[24] This explanation requires that late born players stay active until senior ages, which will not be the case for all sports (e.g., Helsen *et al.* (1998) document higher drop out rates in soccer for relative younger peers during junior and adolescent ages).

difference in popularity between ice-hockey and volleyball in Canada; Helsen *et al.* (1998) for elite playing in youth Belgium soccer; Cobley *et al.* (2009) by using both proxies as moderating variables). Musch & Grondin (2001), furthermore, state that competition is a necessary condition for a RAE to occur. A simple example by Musch & Grondin (2001) makes clear that if only 15 participants compete for 15 available places in a squad, there is no reason for an RAE to occur if the initial selection of participants is random. They also use the evidence of severe RAEs in soccer, combined with the large popularity of the sport, to validate the statement above. With respect to the differences between genders, researchers have argued that the smaller degree of competition in female sports might be an explanation (e.g. Baxter-Jones & Helms, 1994; Musch & Grondin, 2001; Vincent & Glamser, 2006).

Although it is widely assumed that the cut-off date is responsible for the existence of RAEs within sports, some studies have investigated other explanations. Musch & Grondin (2001) discuss the potential influence of the season in which someone is born, which might have consequences for development early in life. However, since December and January are very similar climatically etc., while ice-hockey and soccer use the 1st of January as cut-off date, this explanation is not very convincing. Another possibility that has been investigated is the role of cultural differences between countries that might influence RAEs. Musch & Hay (1999) used data from German, Australian, Brazilian and Japanese soccer to see if differences existed in birth-date distributions, which might then be culturally based, but found for all countries an overrepresentation of the ones born just after the cut-off date.[25] Although the cultural differences within Europe are less severe than between Germany, Australia, Brazil and Japan, Verhulst (1992) and Helsen *et al.* (2005) show that RAEs are alike across European soccer, which is also evidence against the culturally based explanation.

In addition to the fact that other explanations for the RAE to occur are not satisfactory, there exists evidence that the cut-off date is the responsible factor. This evidence is based on the change in cut-off date in soccer during 1997. To comply with the guidelines of the FIFA, national soccer federations changed their cut-off date to the 1st of January if they were not already using this date. Interestingly, after the change in the cut-off date, the RAE also shifted. Helsen *et al.* (2000) and Helsen *et al.* (2000) document, for Belgium youth soccer, a shift in the overrepresentation of players born in August to players born in January, after the Belgium soccer federation changed the cut-off date. Similar results were found by Simmons & Paull (2001) for English youth soccer players and Musch & Hay (1999) for Australian youth soccer.[26]

[25] This finding might, of course, be influenced by the popularity of the sport within the given countries. However, since soccer is popular in all these countries this does not seem to be the case. The FIFA ranking of January 1999 is evidence of the popularity: Brazil was ranked 1, Germany 5, Japan 33 and Australia 50. Brazil, Japan and Australia were ranked highest of their home continent, while Germany was ranked on place 4).

[26] The initial cut-off date in Belgium and Australia was the 1st of August, while for English soccer it was the 1st of September.

The fact that the organizational structure of competitive sport systems (i.e. the cut-off date) is responsible for the occurrence of RAEs, with all its harmful consequences, made researchers think of remedies to the problem. One possibility that has been proposed is to base classification on biological age (Musch & Grondin; 2001). Although this works for sports like wrestling and boxing (e.g. classification based on weight) the absolute age differences, then, can become too large for proper psychological development, while accumulated practice hours might also differ too much (Musch & Grondin; 2001). Other solutions looked at ways to rotate the relative age advantage. For example, Grondin *et al.* (1984) proposed a 15-month or 21-month age category, while Bouchard & Halliwell (1991) preferred a 9-month age band. Both suggestions imply that the advantage of being the relatively oldest would shift to other participants per competitive season.

Although they might work, the solutions that were discussed in the previous paragraph are complex to implement properly, especially when only a low number of participants is active.[27] A solution that does not have such a problem has been proposed by Barnsely & Thompson (1988) and contains the implementation of 'age quotas', i.e. a quota for the number of participants born in a specific period of the year (e.g. quarter). This way of selecting means that, at least some late born players are given the opportunity to develop. Another solution to achieve this would be to use multiple squads based on multiple standards (Musch & Grondin; 2001). A technical superior player who did not yet physically develop, would then be placed in a team with similar peers. This prevents that a physical disadvantage will destroy potential. However, this is a costly method that needs strict supervision, since a lot of coordination and cooperation between clubs, coaches and organizers is needed. On a macro basis, i.e. a country or region in a whole, a solution might be to use different cut-off dates for different sports and other domains. Musch & Grondin (2001) came up with this idea, but also acknowledge that this might not positively contribute to a child's personal development, since the child will be 'forced' to practice a particular sport, perhaps without her close friends.

Overall, the remedies that were put forward, although they have never really been tested, seem to lack practical applicability. Therefore, the most straightforward solution is to make coaches, parents, athletes and all other people involved in sports familiar with the phenomenon of a RAE. Delayed selection, with a focus on individual improvement over time, rather than current performances and winning, might then be acknowledged as useful (Musch & Grondin, 2001; Cobley *et al.,* 2009). Objectivity will be hard to achieve in many sports, but we will see later that for track & field this might be possible. However, before doing that, the next section will give some background information on track & field.

[27]This will be less of a problem with age categories based on 15-months or 21-months, but it might be a problem for 9-month categories or categories based on weight, which, then, need to include a wide range.

4. Background information on track & field and the Dutch system

As mentioned in the introduction, track & field has been an essential part of the Olympic Games throughout history. During the 2012 edition held in London, about 2,000 athletes coming from all over the world will compete in 47 different disciplines, which makes it 'the largest single sport at the games'.[28] The amount of and diversity in disciplines makes it difficult for athletes to specialize in all of them. Therefore, they will only participate in one or two individual disciplines, depending on the similarity of necessary practice and skills (e.g. the 100m and 200m require more or less the same practice and skills).[29] In principal, all disciplines are practiced on an individual basis, with relay racing being an exception.

While the above is true for adult athletes, most of it also holds for junior and adolescent participants. In total, five different age categories exist; D (aged 12-13), C (aged 14-15), B (aged 16-17), A (aged 18-19) and Senior (ages > 19), with the 1st of January being the relevant cut-off date.[30] All categories consist of first year and second year athletes, except, of course, the adult one. Neo (aged 20-22) is a subcategory of the Senior group. Although this could be seen as a sixth age category, no single rankings are made up or championships are held for this group (in contrast to, e.g., Belgian track & field). Therefore, the athletes that belong to the Neo category will not be treated separately and will simply be grouped together with the Senior athletes throughout the text.

A difference between the younger and older age cohorts is that, at younger ages people are more likely to be involved in multiple disciplines, with specialization coming over time. If we assume that the principle goal of an individual athlete is winning, irrespective of the discipline[31], then, within the top tiers of the sport this specialization can be inferred as a self-selection mechanism that results in an efficient allocation of talent over the different disciplines. Athletes will choose to specialize in the discipline in which they have the highest chance of winning, which means they will choose the discipline in which they have a comparative advantage.

Although athletes themselves decide in which disciplines they want to participate, the environment (especially clubs and coaches) have their own interests and may think differently. As said, track & field is an individual sport. However, in the Netherlands, athletes need to be a member of a club to be allowed to participate in competitions and regional, national and international championships. Already for junior athletes an interclub competition exists, consisting of multiple

[28] http://www.london2012.com/athletics.
[29] Of course, some athletes participate in decathlon (males) or heptathlon (females), but this is only a small number, while most of them will be specialized in a particular discipline as well.
[30] Track & field consists of both, an indoor and an outdoor season. Given that the indoor season starts on the 1st of November, most athletes already shift age category. However, relevant for the rankings (more on this in the next section) is the calendar year in which someone is born. The relevant cut-off date is thus January 1.
[31] Thus, assuming that all disciplines are equally enjoyable.

rounds, in which clubs compete against each other within club teams. The athletes who are selected for the team are allowed to participate in only a limited number of disciplines and, thus, choices have to be made.[32] The goal of the club is to earn as much points as possible. These points are earned by the performances of the athletes, in which each performance is converted into a specific amount of points. Without going into detail of how this rather complicated conversion takes place, it is important to note that the quantitative differences between performances are taken into account. An example would be the winner in a long jump competition, who jumps 25 cm further than number two. This quantitative difference in performance (i.e. 25 cm; in other disciplines it might well be some time indication) is more important than the qualitative difference in ranking. The clubs will therefore use a strategy for their team selection that is focused on the current performances. This strategy is, however, not necessarily in line with the interest of the individual athlete, since he might have to do something that does not stimulate his optimal development. We already saw that practice is an essential element for expertise. However, given the interest and influence of clubs, especially early in life, young performers might not practice the things they should.

This conflict of interest is less of a problem between individuals and the track and field federation. The KNAU (Koninklijke Nederlandse Atletiek Unie; in English: Royal Dutch Track & Field Federation) is responsible for track & field in the Netherlands. Although the KNAU has multiple aims, depending on the level of performance, with respect to elite athletes they aim to fully develop their potential. Support is given by the national federation through the provision of expert coaching and training facilities. Already at junior ages there are regional practice sessions organized by the KNAU, in which expert athletes are given such extra attention. At adolescent and senior ages, these regional sessions are replaced by national ones, which are only provided at a few places in the Netherlands.[33] This pyramid structure is used as a selection mechanism, which eventually should result in a situation in which the best athletes are given the attention they deserve. A problem with this selection system is, however, that current performances are the main indicator of who is allowed to participate (see appendix A5 for an example of a table that is used by the KNAU; in Dutch). We already saw for other sports that too much focus on current performances might result in a RAE, while in this situation of extra practice, it is also clear that the ones not selected are missing a relevant experience for development.[34]

[32] In general, athletes are allowed to participate in two individual disciplines and relay racing.
[33] E.g., Pole Vault can only be practiced at Amsterdam, Sittard and Zoetermeer.
[34] On some occasions, the coaches, based on their expertise, are the ones that select athletes. Although this might overcome the problem of too much focus on current performances, we saw in the previous section that coaches and scouts are not yet able to fully understand the RAE and, thus, do not take account of it properly in their selections.

Of course, it would be ideal if all athletes were given equal opportunities to develop. This not only means that the RAE should be dealt with correctly when making a selection for extra practice, but also that the national federation provides sufficient support for top athletes to let them focus on their sport. However, the KNAU is subject to a budget constraint. The consequence is that expert coaching and training facilities are limited, while, furthermore, the KNAU has only little financial means to support athletes. The result is that athletes who want to become and stay top performers need to make a lot of private investment, while the environment needs to be supportive and willing to make some investment as well.[35]

This brief overview of Dutch track & field shows that, in principle, all parties (i.e. individuals, clubs and the national federation) aim for the development of expertise. However, we also saw that some conflicts of interest may arise between individual athletes and clubs. Furthermore, the national federation is not always supporting potential in a correct way. Underlying these problems is the focus on current performances.

Since the aim of this section was to provide background information, not all things related to Dutch track & field were discussed. One thing is, however, worthwhile to mention. Although athletes are a member of a club, they have the possibility to participate in contests outside of the competition and the regional, national and international championships.[36] These contests are of less importance for clubs, while they are only a reference of results for the national federation (although the adult championships are, of course, an important milestone, since these should be the end result of the development of potential). The next section will provide a description of the data that will be used. For that, it is important to keep in mind that, in general, athletes have enough opportunities to perform the best they can during a season.

[35]The organizing body that is responsible for the financial support of top athletes in the Netherlands is the NOC-NSF. In general, one should belong to the best eight athletes of the world (A-status) or have a high probability to become one of them within a few years (HP-status; i.e. High Potential) to be eligible for such financial support. The maximum amount that one can get in 2011 was €1,085.01 gross per month (i.e. 70 percent of the minimum income of a 23 year old person). An extra compensation in costs is provided up to a maximum of €350.- per month. Athletes with a B-status, which generally means that they belong to the best 16 athletes of the world, are only eligible for a compensation in costs of €225.- per month, without any other financial support. If someone already earns more than €35,000.- gross per year, the NOC-NSF does not support any extra. In general this, thus, means that the financial support for athletes is rather small and someone aiming for a top sport career has to make a lot of investment herself. (http://www.nocnsf.nl/nocnsf.nl/olympische-droom/topsportinformatie/voor-topsporters/voor-topsporters)

[36] They, however, still need to be a member of a club to participate in those contests.

5. Data and methodology

Every year the KNAU publishes a statistical yearbook for both, the indoor and the outdoor season. One part of this book consists of the rankings of the year, in which all best performances are grouped by gender, age category and discipline. Each record within those rankings documents the performance, name, birth date, club and the date and place of the match where the result was set. For disciplines in which this is considered relevant, the wind speed is also indicated, since tailwind is generally an advantage.[37] An extra indication is used for results set during an intra-club match, if the result was recorded without electronic device (for sprinting and hurdles) and for results obtained by foreigners (who are a member of a Dutch club). Finally, it is possible that younger athletes obtain a result that places them in the rankings of an older category, which is indicated as well. The rankings are made up in such a way that only someone's personal season best is taken into account.[38]

These official rankings will be used in this study.[39] Another possibility would be to use the final rankings of important competitions, such as the national championship. However, the official rankings are preferred. First of all, these data allow for a larger sample size. Furthermore, the rankings consist of the performances of the whole season and are thus not confounded by, for example, a temporary injury during the championship. Finally, the rankings consist of the best performances throughout the season and are, thus, not confounded by the fact that athletes are focused on winning during a national championship and, therefore, not necessarily perform at their best. This final point might, however, be of little importance, since the championships are in general the matches in which athletes are trying to peak and need to perform as good as they can to win.

The sample consists of eleven seasons, from 2000 up to and including 2010. Only data on the outdoor season will be used, since this is more important than the indoor season for most athletes (the two most popular competitions are the Olympic Games and the Diamond League, which are both outdoor). Furthermore, a selection will be made of the disciplines that will be covered. An overview of these disciplines, with an indication of the relevant age categories, is presented in appendix A1. The sample sizes, specified per age category, can be found in table 1 below. Most of the data comes from the Senior age category. This mainly has to do with the fact that those rankings include more performances than the rankings for younger athletes.

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[37] These disciplines are: 60m, 80m, 100m, 150m, 200m, hurdles short and long jump. Triple jump also belong to these disciplines, but is not considered in this text.

[38] An exception is made for the adult rankings, were at least the ten best performances are shown, despite that the athlete might already be ranked higher. Furthermore, the results with an extra indication (e.g. an intra-club match) are separated from the rest and may be obtained by someone already in the 'regular' ranking, which is possible for all age categories.

[39] The publications of the statistical yearbook are made available on the website of the KNAU: http://www.atletiekunie.nl/index.php?page=949. Most yearbooks have been updated recently. However, these updates are not incorporated in this study and, thus, insofar these updates caused changes in the official rankings, they are not taken into account.

Table 1: sample sizes, specified by gender and age categories

Males		Females	
Age category/Quarter	n	**Age category/Quarter**	n
Males-D	2,400	Females-D	2,650
Males-C	3,376	Females-C	3,018
Males-B	3,046	Females-B	2,421
Males-A	3,978	Females-A	2,498
Males-Senior	10,143	Females-Senior	4,333
Total	22,943	*Total*	14,920

As said in the beginning of the section, it is possible for younger athletes to obtain results that place them in a ranking of an older age category. In such cases the result will logically also occur in the ranking of the age category where the athlete belongs to. Using such data would mean that the same person with the same result would count multiple times. For this reason, the result is dropped from the older age category.[40] Furthermore, all results obtained without electronic time device and all results obtained during an intra-club match are dropped. In addition, all foreigners are dropped from the rankings, with the athletes coming from the former Netherlands Antilles being an exception, since they have a very strong connection with the Netherlands. Finally, after consultation of multiple sources, there were some athletes whose birth date was not available and, therefore, had to be dropped from the sample.[41] Ideally, all results obtained without a wind speed indication or with too much tailwind (tailwind > 2) should be excluded. However, since leaving out all results without wind indication would decrease the sample size for the relevant disciplines significantly (see footnote 37 for the relevant disciplines), especially for the early seasons within the sample. Therefore, wind speed is not taken into account. Although this is not ideal, it should be noted that the composition of athletes will not change much, since the ones with a correct wind indication, are most likely also the fastest without wind indication. It does, however, favor the results with too much tailwind.

The empirical analysis will be split into two parts. Part 1 will investigate the RAE for Dutch track & field. This is done by looking whether the distribution of birth dates is different from what may be expected. Preferably this should be done by comparing the distribution as found in the data with actual birth dates in the Netherlands. However, since multiple seasons are grouped together, there is no single 'actual' birth date distribution for a given age category.[42] Therefore, the expected

[40] As can be seen in appendix A1, the disciplines that use a specific weight (javelin, shot put and disc throw) and height (hurdles) tend to become similar to the senior rules at an earlier age for females than for males. This means that it is easier for females to achieve a result that places them in a higher ranking than for males. Therefore, more female than male results will be dropped for this reason.

[41] Only 102 observations had to be dropped for males and 57 observations for females.

[42] This would mean that for each junior and adolescent age category, 22 age distributions should be combined (eleven for the first year athletes and eleven for the second year athletes), while for adults the number of relevant distributions is much larger.

distribution is assumed to be a uniform distribution.[43] Then, insofar giftedness or talent is independent from someone's birth date, a difference between what is found in the data and what is expected, means that an RAE exists. A χ^2 goodness-of-fit test will be used to investigate this, while an Odds Ratio between the first half of the year and the second half of the year should indicate if the skewness of the distribution is in the right (expected) direction.

Part 2 will use the objective performances as dependent variable in a regression analysis. Interest will be in the performance differences between athletes that are born in different quarters. The independent variables will, therefore, consist of three dummies for quarter two, quarter three and quarter four. Furthermore, a ranking of clubs is included next to season fixed effects. More details will be explained in the next section, in which the results are shown.

[43] An investigation of actual birth dates in the Netherlands shows that, in general, there are more people born in the third quarter of the year than in the other quarters. Although this will not be taken into account, it means that, given that the cut-off date is the 1st of January, the results might underestimate the strength of the RAEs.

6. Results

In this section the results will be presented. As discussed above, this section consists of two parts. In part 1 the RAE in elite Dutch track & field will be investigated, for both males and females. Besides looking at the aggregate data per age category, we will also look at a subdivision per discipline, year indicator (first- and second-year athletes) and season. Part 2 will look at the performance differences between early and late born peers.

6.1 Part I: the RAE

In line with (most) other literature on a RAE in sport, the hypothesis for this study is to observe an overrepresentation of participants born close after the cut-off date. To investigate this, birth dates are group by quarter, in which the quarters correspond to the calendar year. Thus quarter one corresponds to January, February and March, while quarter 4 corresponds to October, November and December.

Columns 2 up to and including 5 of table 2 (for males) and table 3 (for females) present the distribution of birth dates per quarter for the five different age categories. For all male age categories, quarter one contains more participants than the other quarters. For females this only happens for the D- and C-categories. The other female groups contain slightly more participants born in the second quarter than in the first. With respect to the final quarter, the observed is consistent to what was expected, since for both males and females and for all age categories, the lowest number of participants are born in quarter four. Furthermore, it can be seen that the biggest differences between this last quarter and the first (or second) quarter are present in the youngest age categories (D and C).

A graphical representation is given in figures 1 and 2. Figure 1a and 2a show the distribution of birth dates for respectively the junior and adolescent male and female athletes. Figure 1b and 2b show the same for respectively the senior male and female athletes (note, however, the difference in axis between the figures a and b). The separation of the adult categories from the other age categories is mainly done because the adult groups may contain the same individuals multiple times, when subsequent seasons are combined. Although this might also occur within the younger age cohorts, which contain first and second year athletes, the influence on the data will be less severe, since an individual will occur no more than twice within an given age category throughout the sample period. A comparison of the data for adults and younger athletes, that covers all seasons, will not take this difference into account. Below it will be shown, however, that things do not change much if we separate the data by seasons and distinguish for the junior and adolescent age categories between first- and second-year athletes.

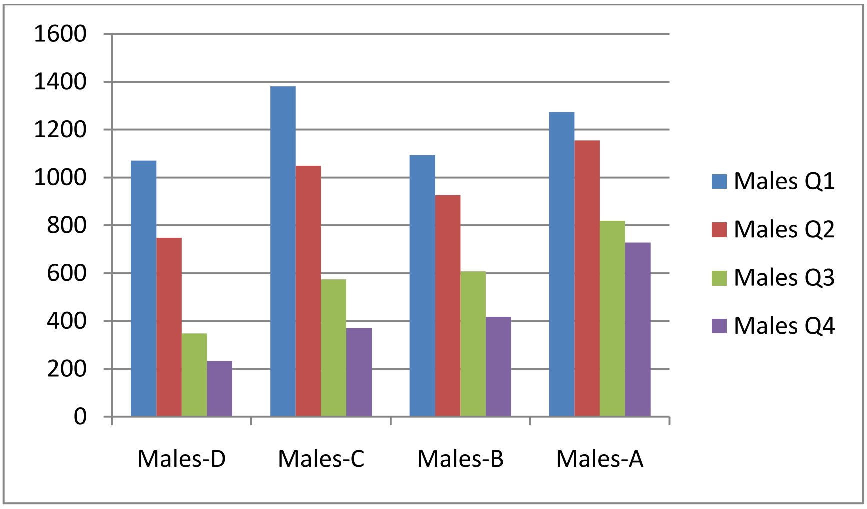

Figure 1a: total number of observations for male athletes per age category (except adults), split by quarter of birth

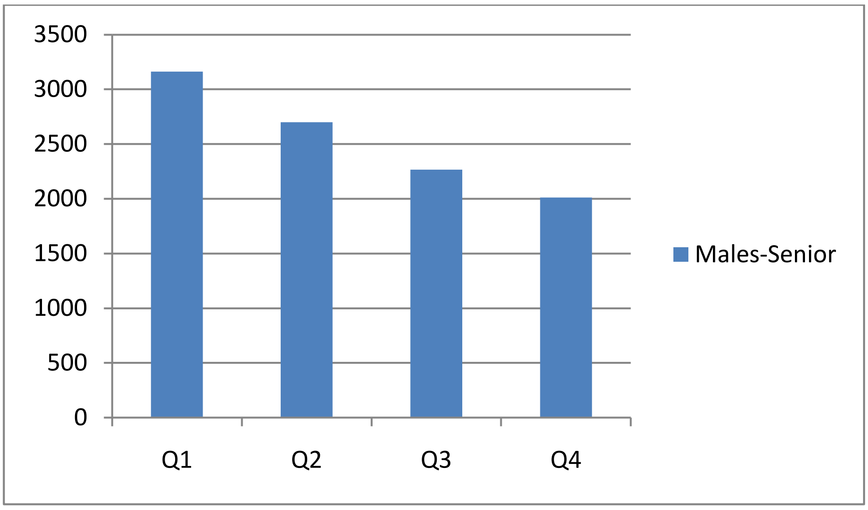

Figure 1b: total number of observations for male senior athletes, split by quarter of birth

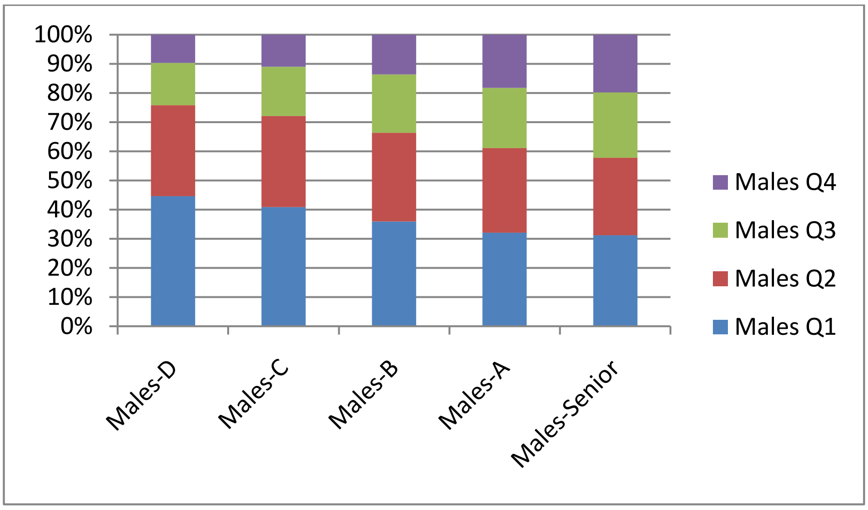

Figure 1c: share of the number of male athletes born within a given quarter, per age category

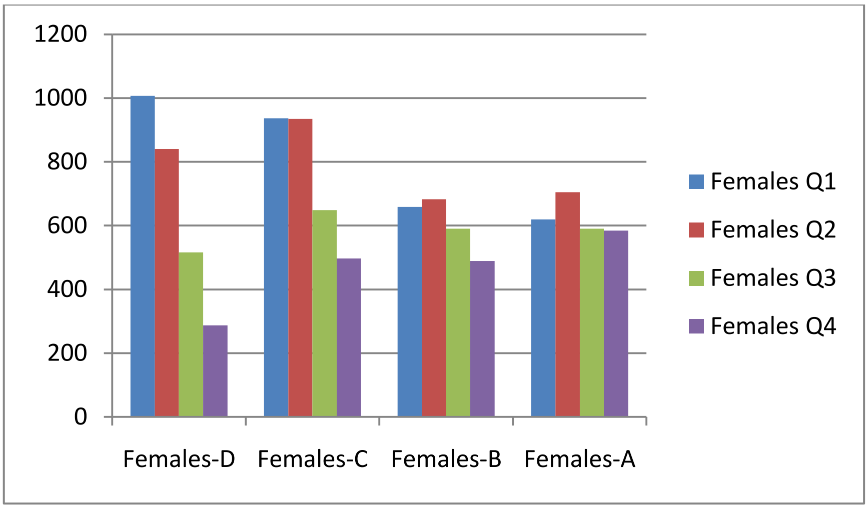

Figure 2a: total number of observations for female athletes per age category (except adults), split by quarter of birth

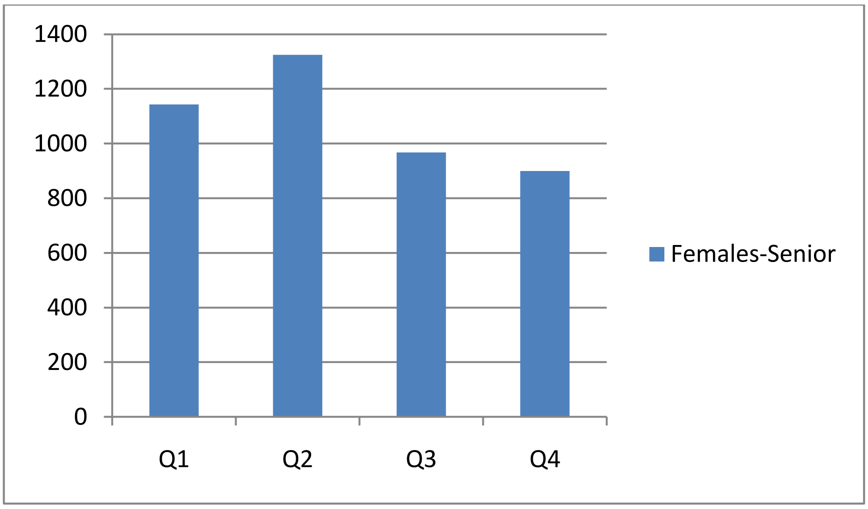

Figure 2b: total number of observations for female senior athletes, split by quarter of birth

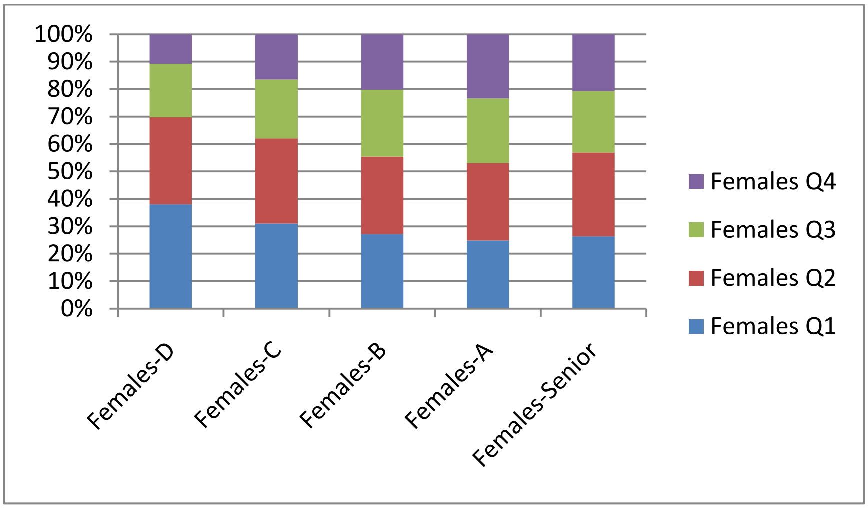

Figure 2c: share of the number of female athletes born within a given quarter, per age category

Furthermore, figures 1c and 2c show for respectively males and females the percentages of births per quarter and per age group. In both figures, when going from left to right, thus moving up the chronicle age cohorts, it can be seen that the share of early born participants decreases, while the share of late born athletes increases. To make this point clearly visible, all age categories are put together in one graph, with, however, in mind that the Senior categories might contain the same athletes multiple times.

Table 2: distribution of birth dates per quarter for male athletes

Males	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Age category/ Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
Males-D	1,071	748	348	233	2,400	736.56	0.00	9.80
Males-C	1,381	1,050	574	371	3,376	743.41	0.00	6.62
Males-B	1,094	926	608	418	3,046	366.61	0.00	3.88
Males-A	1,274	1,155	820	729	3,978	205.95	0.00	2.46
Males-Senior	3,163	2,700	2,267	2,013	10,143	302.05	0.00	1.88
Total	7,983	6,579	4,617	3,764	22,943	1,900.47	0.00	3.02

Table 3: distribution of birth dates per quarter for female athletes

Females	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Age category/ Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
Females-D	1,007	840	516	287	2,650	471.92	0.00	5.29
Females-C	937	935	649	497	3,018	189.96	0.00	2.67
Females-B	659	683	590	489	2,421	37.47	0.00	1.55
Females-A	619	705	590	584	2,498	14.96	0.00	1.27
Females-Senior	1,143	1,324	967	899	4,333	100.62	0.00	1.75
Total	4,365	4,487	3,312	2,756	14,920	562.92	0.00	2.13

The above showed that it seems very likely to find a RAE as was hypothesized. Statistical inference indeed shows that this is the case. Column 7 of tables 2 and 3 provide the χ^2 goodness-of-fit statistic, with the p-value indicated in column 8. All statistics are highly significant, with all p-values smaller than 0.00 for both males and females, indicating that the distribution of birth dates is far from uniform. Furthermore, the Odds Ratios in column 9 between the first and second half of the year show that the skewness of the distribution is in favor of the early born athletes for all age categories, since all values are above 1.[44] Based on these combined results, we can conclude that a RAE exists in elite Dutch track & field, which is as expected. Furthermore, we observe that both the χ^2 statistic and the OR decline in value for older age groups, while they slightly increase again for adults (except the OR for male adults). This means that, at least for the junior and adolescent age groups, we may conclude that the strength of the RAE declines when athletes become older. This

[44] A value above 1 indicates an overrepresentation of early born athletes, while a value below 1 indicates an overrepresentation of late born athletes.

conclusion is evidence in favor of the hypothesis that a RAE arises due to a physical advantage of early born athletes. However, we will postpone this discussion to section 7, in which all results will be discussed.

As mentioned, the data as shown in the tables 2 and 3 and the figures 1 and 2 is grouped together over the different seasons, disciplines and year indicator. Separation was only based on age cohorts. However, such a broad classification may not uncover some potentially interesting trends. Therefore, a further division of the age categories was made. The results can be found in appendix 2. Tables A2a and A2b show the results per age category, subdivided into the different disciplines, for respectively males and females. Without going into too much detail, it becomes clear that the significance of the general results also holds for the single disciplines for male athletes, with the long distance being an exception.[45] In contrast, for female athletes we observe clear differences, especially for the B-, A- and Senior-category. Again the long distance disciplines (3,000m, 1,500m), but also the middle distance (800m), are deviating. Furthermore, some other disciplines are different from the general findings (e.g. 100m and pole vault). The results of the subdivision into seasons can be found in tables A2c (males) and A2d (females). Here we see again that for males, with the exception of 2008 and 2009 of the A-category, all classifications show a RAE in line with the hypothesis. For females, the results are, however, not that consistent over the years, with the deviations from the general findings mostly occurring in the older age categories (B, A and Senior). The final subdivision is to separate the first and second year athletes within each age cohort. Tables A2e (males) and A2f (females) show the results and, for a better comparison, also include the different disciplines. To be complete, the tables also include the Senior-category, which cannot simply be split into first and second year athletes, since adult athletes may be within the rankings for many more years. For males (table A2e) we see that the difference between the first- and second-year athletes with respect to the RAE are rather small. Noteworthy is, however, the difference in the number of athletes, which is huge for the youngest group (D-1 year: 257 vs. D-2 year: 2,143), but reduces to only a marginal difference (A-1 year: 1,941 vs. A2-year: 2,037). For females (table A2f) the differences with respect to the RAE tend to be similar between the first and second year athletes. However, by splitting up the age categories the overall (*total*) significance of the female A-cohort decreases. Interesting is further that the differences in the number of first and second year athletes tend to be smaller than for males, with the A-category containing even more first year than second year athletes (D-1: 521 vs. D-2: 2,129; and A-1: 1,315 vs. A-2: 1,183).

[45]The 5,000m for the A-category has a p-value of 0.54 and an OR of 0.85; the 5,000m for the Senior-category has a p-value of 0.03 and an OR of 0.77. The results for the A-category and adults for the 1,500m are rather similar as the 5,000m, but are, however, less severe.

To summarize part 1 of this section, we have found evidence for the existence of a RAE within elite Dutch track & field, for both males and females. Within all age categories significant results were obtained. Furthermore, after subdivision of the data, most of the results did not change much, which indicates consistency between disciplines and over years. We also found a diminishing persistence of the RAE when athletes become older, at least within the junior and adolescent age categories. This especially happened in the B and A groups for females. Potential reasons will be discussed in section 7, in which also more attention will be paid to the differences in results for males and females. Before doing so, the next part will look at the performance differences, which might result in a method to better compare the performances of early and late born peers.

6.2 Part II: performance differences

The previous part showed that a RAE is present within elite Dutch track & field. In this part, it will be investigated how this age effect relates to the performances of athletes. The primary hypothesis is that older athletes perform better. This difference in performance is expected to exist not only between age groups, but also between peers within the same group. It is, thus, expected that early born athletes perform better than their younger peers. While in many sports it is hard to test this, since no objective performances are available, track & field does provide such data. By performing a regression analysis on this data, it will be possible to test if significant differences exist. If so, this is evidence indicating that the selection system, in which selection is based on current performances, is, at least partly responsible for the RAE as found above. Furthermore, the estimation results can be used to better compare the results of early and late born participants, which might be a solution to the problem.

As said, the expectation is that older athletes perform better than younger ones. This expectation is based on the principle that athletes develop over time, by e.g. practice. However, it is reasonable to assume that this development will stagnate at some point, and will eventually turn negative. A logical consequence of the quadratic relation between age and performance is that the differences between early and late born peers are larger at younger ages. This because the relative age advantage (difference) is then larger. It can therefore be expected that any significant results are more profound for the junior age categories (i.e. D and C) than for the older ones (i.e. B and A). Results that indicate that this expectation is true are in line with the observation of a decreasing strength of the RAE, since this also indicates that the late born participants are closing the gap.

The sample that will be used in this part is similar to that used in part 1 of this section. However, not all data will be used in the analyses. First of all, the sample contains the disciplines 400m (for both genders), 5,000m (for males) and 3,000m (for females). The data for these disciplines only covers the adolescent and senior age categories (B, A and Senior) and these disciplines are therefore left out of the analyses. Secondly, and perhaps more important, a selection of athletes will be used in the analyses. Given the existence of a RAE, the sample contains more early born athletes than late born athletes. Using the performances of all these individuals would mean that an unequal number of observations per quarter would be used. Insofar these 'extra' early born athletes perform worse than their late born peers, the results are blurred. To correct for this, only the best performances per quarter are used.

The procedure is as follows. For each discipline, the sample is split into age categories and further divided by year indicator (except for the adult group). The seasons are, however, grouped together. Next, for each selection (i.e. for a given combination of discipline, age category and year indicator) and per quarter, a ranking is made of the performances. From all quarters, only a number of the best performances are kept, where the number is equal to the number of observations of the quarter with the least observations (which in many cases will be the fourth quarter). In this way an equal number of observations per quarter will arise. A deviation to this might occur, however, if results within a quarter are equal, but would not all be included by the procedure above. In such a situation, all these equal observations are included. An example would be if only 25 observations per quarter should be included, while observation 25 and 26 of the first quarter are both 1.80m for high jumping. This exception to the general procedure is important, since other variables are included as well, which not necessarily have the same value.

Related to the dropping of observations to obtain an equal number per quarter is that for some selections (discipline, age category and year indicator) only a small number of observations is left. In general, it was decided to drop the results of a selection if the number of observations was smaller than 50, which mostly happened for the first year categories.

The model that will be tested is as follows:

$$Performance_i = \alpha + \beta_1 Q2_i + \beta_2 Q3_i + \beta_3 Q4_i + \beta_4 Clubranking_i + \beta_5 Season_t$$

In which $Performance_i$ is the result obtained by an individual *i*, which can be a distance in meters or a time in seconds, depending on the discipline. Interest is in $Q2_i$, $Q3_i$ and $Q4_i$, which are dummies that have a value of one if the individual is born in respectively the second, third or fourth quarter (thus, the first quarter is used as base category). Furthermore, $Clubranking_i$ is included as a proxy for the level of the club an individual is a member of (e.g. facilities, financial support).[46] Finally,

[46] The value is discipline specific and is based on the rankings of the adult athletes, which is then transmitted to the junior and adolescent groups. The club of the best performer was given a value of one, the second best a value of two and so forth up to ten. All other clubs were given a value of eleven. Since these rankings of the

season dummies were included ($Season_t$) with the year 2000 being the omitted dummy. Since only a sub selection of the sample will be used (see the selection procedure described above) not all seasons will occur in equal numbers. For this reason, they cannot directly be interpreted as representing a time trend. However, they do control for seasonal fixed effects, such as the general weather conditions during a particular season.

Summary statistics of the performances per discipline and split by age category can be found in appendix A3 in tables A3a (for males) and A3b (for females). Note that these statistics cover the whole sample, without taking into account any of the selections as described above. Furthermore, note that some disciplines are grouped together (e.g. long distance contains 1,000m as well as the 1,500m) to make a better comparison between age categories. The actual discipline that belongs to a particular age category is indicated between brackets in the top row of each sub-table. Here is also some extra information given of particular weights (for javelin, shot put and disc throw) or heights (for hurdles).

The regression results are presented in tables 4 (males) and 5 (females). For convenience, these tables only include the main results on the variables of interest and the number of observations. Appendix A4, tables A4a and A4b provide more detailed information on the results. In all these tables (4, 5, A4a and A4b) the character in the top row of a column represents the age category, while the figure following this character indicates if the results belong to first or second year athletes. Senior is an exception in this respect. When interpreting the results, it is important to remember the difference between performances expressed as a distance and as a time. For 'distance', a positive relation exists between distance and performance (i.e. further or higher is better). For 'time', a negative relation exists, since faster means a better performance. In line with the hypothesis as formulated in the beginning of this part, we expect negative coefficients for the 'distance-disciplines' and positive coefficients for the 'time-disciplines'.

When looking at table 4, two things require primary interest. First of all, almost all coefficients have the expected sign, and second, the coefficients are significant in many occasions. Some exceptions are visible for the second quarter, which might especially differ for the older age categories (e.g. Javelin and Shot Put). However, despite these exceptions the results indicate that, on average, late born athletes perform worse than their early born peers. Interesting is further, that significance is generally more profound and consistent when moving away from the first quarter

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clubs were transmitted from the adult category to the younger age groups, it was possible that those younger athletes were a member of a club not represented in the adult rankings. These clubs were given a value of twelve. If a discipline of the junior age categories did not coincide with that of the adults, the most similar discipline of the adult rankings was used (appendix A3 shows, between brackets, which disciplines were grouped together). Furthermore, if a club already appeared higher in the rankings, it was given this higher ranking. The next value was given to the first new club in the rankings.

towards the end of the year, with higher estimation results in absolute value. This is in line with what was expected, based on the stagnation of development and the diminishing performance gap between peers.

The results, thus, indicate that significant differences exist between the performances of early and late born peers. However, significance does not necessarily mean that the estimations are of practical relevance. Let us formulate how a coefficient should be interpreted by using as an example the -0.433 for Q4 under Long Jump category C-2. This means that at an age of 15, on average, someone born in the fourth quarter will jump 43.3 cm less far than someone born in the first quarter.[47] Besides that it is a firm distance when visualizing it, it is also a substantial difference when evaluated on the summary statistics. Without checking all results this way, it seems fair to state that the differences as found for males are of practical relevance, especially for the younger age categories.

Table 5 presents the female results.[48] It can be seen that the signs of the coefficients are not consistently in line with what was expected. Especially for quarter two the sign tends to differ. However, these results are often not significant, indicating that the first and second quarter athletes are performing more or less equally well. With respect to quarter three and quarter four, we observe that the results as presented in table 5 seem to behave in the same way. Although some differences exist (mostly for Long Distance, Middle Distance and Hurdles Long) the signs and significance levels are rather similar. Furthermore, they tend to be in line with expectations for the junior age categories. For the older age categories, the results do not meet expectations. Combined, this implies that, given the number of insignificant results, the practical relevance is limited to the youngest athletes.

Summarizing then, we found significant performance differences between early and late born peers for both males and females. As expected, the results increased in strength when moving away from the first quarter towards the end of the year. Furthermore, also as expected, when moving up age cohorts, the effects on performances tend to decrease. This diminishing effect was more profound to female athletes than to male athletes. The practical relevance of the estimation results will therefore be larger for males than for females. A more comprehensive comparison between the genders will be postponed to the next section.

This section will end with two final remarks. First of all, no attention was paid yet to the 'clubranking' variable. In tables A4a and A4b of appendix A4 it can be seen that the signs of the

[47] The regressions were also done by using the natural logarithm of the performances, but results did not differ much. An advantage of the way they are presented now is, however, that the estimations can be interpreted as a real number (meters or seconds) and not as a percentage. Therefore, this method is chosen.

[48] Note that Pole Vault is not included, since C-2, B-2 and Senior were the only categories that contained enough observations.

coefficient is almost always as predicted (the prediction is a negative coefficient for 'distance-disciplines' and a positive coefficient for 'time-disciplines', since a lower value means a better club). However, it is only significant for the adolescent and adult groups. More on this variable will follow in the next section. Furthermore, no special attention was paid to the results of the senior age category. However, the remark that senior rankings may contain the same individual multiple times when grouping over seasons, which was made at the beginning of part 1, is also valid here. In light of this, one should be cautious when interpreting these results or when comparing them to other age groups.

Table 4: estimation results for male athletes

Long Jump (distance)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	-0.062	-0.172**	-0.061	-0.083	-0.048	-0.091**	
Q3	-0.371**	-0.260**	-0.104*	-0.160**	-0.144*	-0.162**	
Q4	-0.460**	-0.433**	-0.301**	-0.270**	-0.216**	-0.110**	
Constant	5.376**	6.438**	6.679**	6.889**	6.999**	7.411**	
n	106	100	99	89	102	487	
High Jump (distance)	**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**
Q2	-0.006	-0.018*	-0.021	0.011	-0.004	-0.005	-0.045**
Q3	-0.032**	-0.050**	-0.025	-0.034**	-0.029*	-0.039*	-0.078**
Q4	-0.051**	-0.050**	-0.041**	-0.018	-0.022	-0.028	-0.061**
Constant	1.586**	1.840**	1.929**	1.939**	1.946**	2.003**	2.150**
n	227	205	93	135	87	84	358
Pole Vault (distance)	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**		
Q2	-0.196*	-0.046	-0.050	0.023	-0.150**		
Q3	-0.267**	-0.086	-0.082	-0.173	-0.302**		
Q4	-0.680**	-0.166	-0.324**	-0.337**	-0.410**		
Constant	3.531**	4.176**	4.431**	4.698**	5.206**		
n	81	109	107	79	488		
Javelin (distance)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	0.506	0.326	-0.370	0.109	0.630	0.436	
Q3	-3.774**	-3.559**	-1.606	-1.933	-2.391*	-3.470**	
Q4	-5.331**	-4.842**	-5.072**	-4.619**	-4.962**	-4.030**	
Constant	43.683**	50.499**	60.114**	59.907**	60.322**	68.374**	
n	100	104	73	88	128	476	
Shot Put (distance)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	-0.120	-0.132	0.516	0.084	0.179	-0.477**	
Q3	-1.300**	-0.778**	-0.191	-0.861**	-0.658	-0.342**	
Q4	-1.318**	-1.397**	-1.301**	-1.100**	-0.929**	-1.317**	
Constant	12.530**	14.451**	16.386**	13.702**	15.391**	17.517**	
n	96	92	69	84	116	685	
Disc Throw (distance)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	-1.826*	-2.438**	-1.777	-2.028	-1.435	-2.477**	
Q3	-4.797**	-4.537**	-3.968**	-4.317**	-4.226**	-1.146**	
Q4	-5.317**	-5.748**	-5.247**	-4.933**	-3.243*	-2.040**	
Constant	32.596**	48.227**	47.670**	43.440**	53.469**	54.736**	
n	100	92	72	77	84	789	
Hurdles Short (time)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	0.001	0.177*	0.165	0.244	0.208	0.019	
Q3	0.487**	0.500**	0.338**	0.376**	0.577**	0.014	
Q4	0.747**	0.913**	0.950**	0.745**	0.801**	0.470**	
Constant	12.481**	13.833**	14.570**	14.667**	14.191**	14.204**	
n	86	85	85	116	112	508	
Sprint (time)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	0.099*	0.198**	0.234**	0.143**	0.100	0.015	
Q3	0.399**	0.290**	0.174**	0.171**	0.137**	-0.006	
Q4	0.650**	0.402**	0.368**	0.276**	0.337**	0.157**	
Constant	10.089**	11.356**	11.123**	10.841**	10.825**	10.620**	
n	88	84	88	110	119	686	
Hurdles Long (time)	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**		
Q2	0.726**	0.300	1.464**	1.587**	0.315*		
Q3	2.542**	2.918**	3.557**	3.128**	0.925**		
Q4	3.548**	2.729**	2.213**	3.857**	1.902**		
Constant	40.746**	54.675**	52.860**	51.311**	51.129**		
n	105	84	92	84	438		
Middle Distance (time)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	-0.167	0.070	1.131**	1.149**	0.587	0.489**	
Q3	3.463**	4.077**	1.191*	2.761**	1.596**	1.306**	
Q4	5.941**	3.182**	1.826**	2.557**	1.673**	0.173	
Constant	93.764**	125.940**	116.985**	112.950**	111.042**	108.589**	
n	40	132	112	137	148	701	
Long Distance (time)	**D-2**	**C-2**	**B-2**	**B-1**	**A-1**	**A-2**	**Senior**
Q2	2.093**	-0.918	0.971	-0.099	-2.508*	0.853	-1.221**
Q3	6.595**	4.462**	1.184	0.163	0.045	1.130	1.115**
Q4	8.476**	5.646**	3.994**	4.086**	1.190	2.457	-1.562**
Constant	174.796**	262.785**	247.517**	243.674**	240.546**	231.181**	225.902**
n	108	148	65	116	136	168	676

*Note: all results are obtained by using robust standard errors. **p<0.05, *p<0.1*

Table 5: estimation results for female athletes

Long Jump (distance)	**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**Senior**		
Q2	-0.111**	0.038	-0.005	0.088	0.099	0.209**		
Q3	-0.184**	-0.063	-0.084	0.039	0.043	0.116**		
Q4	-0.236**	-0.080*	-0.041	0.035	-0.026	0.155**		
Constant	4.990**	5.265**	5.456**	5.604**	5.816**	5.812**		
n	89	113	80	76	84	282		
High Jump (distance)	**D-2**	**C-1**	**C-2**	**B-1**	**B-2**	**A-2**	**Senior**	
Q2	0.002	-0.009	-0.015**	0.002	0.030**	0.014	0.067**	
Q3	-0.045**	-0.041**	-0.010	-0.011	0.003	0.027	0.024**	
Q4	-0.057**	-0.039**	-0.011	-0.014	0.022	-0.023	0.032**	
Constant	1.529**	1.592**	1.641**	1.743**	1.704**	1.788**	1.749**	
n	221	82	238	86	82	76	231	
Javelin (distance)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**		
Q2	-1.190	-0.271	0.700	0.556	0.921	1.003		
Q3	-4.127**	-3.772**	-1.384	-2.952**	-0.724	-0.380		
Q4	-4.262**	-4.020**	-1.630	-2.601**	-3.102**	-2.427**		
Constant	34.210**	38.298**	44.176**	50.344**	49.754**	51.746**		
n	136	104	76	76	80	184		
Shot Put (distance)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**		
Q2	0.536	0.800*	0.742*	0.496	0.462	0.509**		
Q3	-0.999**	-0.580*	-1.016**	-0.552**	-0.481*	-0.354*		
Q4	-1.510**	-0.665*	-0.876**	-0.252	-0.141	0.228		
Constant	13.339**	12.589**	15.556**	11.873**	13.442**	14.818**		
n	68	94	76	113	96	240		
Disc Throw (distance)	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**		
Q2	3.337**	1.662	2.767**	2.320	2.959*	2.957**		
Q3	-1.929**	-2.539**	-4.255**	-4.085**	-3.337**	-0.397		
Q4	-2.321**	-4.191**	-3.548**	-3.215**	0.019	2.729**		
Constant	29.544**	35.441**	41.135**	44.940**	44.420**	50.908**		
n	104	84	68	64	56	184		
Hurdles Short (distance)	**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	0.030	-0.072	-0.571**	-0.401**	-0.760**	-0.628**	-0.395**	
Q3	0.276**	0.137**	-0.145	0.003	0.060	-0.169	0.384**	
Q4	0.459**	0.186**	-0.036	0.001	0.058	0.005	0.170	
Constant	9.525**	12.311**	15.217**	14.640**	15.382**	14.962**	13.862**	
n	84	129	85	94	92	80	197	
Sprint (time)	**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	-0.024	-0.033	-0.041	-0.004	-0.090	-0.134*	-0.179**	
Q3	0.062**	0.077*	0.061	0.168**	0.101	0.074	-0.007	
Q4	0.093**	0.076*	0.039	0.100	0.010	0.158**	-0.243**	
Constant	8.246**	10.470**	12.289**	12.029**	12.430**	12.485**	11.968**	
n	124	132	93	104	112	108	241	
Hurdles Long (time)	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**			
Q2	-0.307	0.746	1.370	-0.809	-0.401			
Q3	0.954**	2.467**	1.730*	3.957**	2.304**			
Q4	0.300	-0.149	1.978*	2.562**	1.126**			
Constant	47.641**	59.379**	62.905**	62.407**	58.450**			
n	112	68	100	56	192			
Middle Distance (time)	**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**	
Q2	1.355**	-0.233	-1.025	0.815	-0.852	1.354	0.048	
Q3	2.144**	0.499	-2.824**	-0.563	-0.772	2.717*	0.985**	
Q4	3.322**	0.688	2.057	3.052**	1.449	3.237**	3.255**	
Constant	96.248**	99.314**	133.811**	133.606**	135.835**	128.345**	123.756**	
n	88	120	68	84	104	84	244	
Long Distance (time)	**D-2**	**C-1**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**
Q2	1.019	22.027	2.140	-17.240	2.870	16.554**	4.858	-5.842
Q3	1.945*	22.210	-8.967	-31.367**	1.780	4.257	2.455	-7.737
Q4	5.228**	41.397**	45.731**	16.913*	6.950	3.904	3.514	9.798
Constant	184.089**	222.786**	209.358**	248.141**	223.912**	197.147**	237.037**	216.786**
n	104	144	152	72	84	88	72	300

*Note: all results are obtained by using robust standard errors. **p<0.05, *p<0.1*

7. Discussion

The previous six sections all covered a single element which helped to understand the concept of an RAE and in particular how this relates to elite Dutch track & field. In this section the content of the previous sections will be combined. This will be done by a discussion of multiple topics in separate subsections: the RAE revisited; selection systems; gender differences; limitations and further research; and other applications.

7.1 The RAE revisited

We saw that the concept of an RAE is a know and accepted phenomenon within many applications, such as school systems (Angrist & Kruger; 1991; Plug; 2001), sports (Musch & Grondin; 2001) and even suicide rates (Thompson *et al.*; 1999). Generally, the existence of an RAE is established by comparing the observed and actual or theoretical birth date distributions. However, this procedure only moderately reveals potential mechanisms that cause it to occur. Without the knowledge of these causes it is hard to solve the problem.

In section 3, where related literature on the RAE in sports was reviewed, it became clear that some elements, though in an interconnected way, are generally seen as being responsible for the RAEs that were found. One of them is the use of a strict cut-off date, which separates age groups and is part of the organizational structure of the sport in question (e.g., Helsen *et al.*, 2000; Simmons & Paull, 2001). Others are the level and amount of competition (e.g., Musch & Grondin; 2001) and the physical development of athletes (Sherar *et al.*, 2007), which both are less controlled by the governing body.[49]

Relating this to elite Dutch track & field, we found in the first part of section 6 an overrepresentation of early born athletes, especially for the junior age categories, which is, thus, indicating that the cut-off date is an important element within this sport as well. With respect to the competitiveness of the sport, the evidence is less clear cut. Since only data on the elite level is used, the conclusions can only be based on this level. Furthermore, with a total of 133,057 members on 31 December 2009 (69349 males, 63708 females)[50], track & field was the eighth most popular sport in the Netherlands.[51] This means we can only say that the amount of competition seems to be high enough for a RAE to occur.[52] Finally, since early physical development can in general be seen as an

[49]Although the role of performance based selection systems and the differences with respect to gender could also be mentioned here, it was decided to discuss them in separate subsections and, thus, to neglect them in this part.

[50] Source: official data published by the KNAU: http://www.atletiekunie.nl/index.php?page=475.

[51] Source: http://www.nocnsf.nl/cms/showpage.aspx?id=5180.

[52]Since the official rankings of the KNAU are used, and those represent the top performances within the Netherlands, this study is about elite track & field. However, good athletes that used to belong to the elite group and who still participate within track & field competitions, but decided not to practice as hard as they

advantage in track & field, this might also be an explanation of the overrepresentation of early born athletes. As Musch & Grondin (2001) note, a decline in the severity of the RAE when athletes become older also indicates that physical development is an important factor. This because the physical advantage of early born athletes might have disappeared at older ages, since late born peers have developed then as well. A precondition for this to hold is, of course, that the late born athletes do not drop out at early ages. Given that we found in section 6 such a decline as meant by Musch & Grondin (2001), it can be concluded that physical development is indeed a factor in the occurrence of the RAE in elite Dutch track & field.

The end of section 3 was used to discuss some solutions to the problem of an RAE that were proposed within the literature. These solutions were: a biological age classification, a rotating relative age advantage (9-, 15- or 21-month age categories), age quotas, multiple teams based on multiple standards and, on a macro scale, the use of different cut-off dates. The conclusion in section 3 was that most of them suffered from practical applicability. Without discussing them one by one, this also seems to hold for track & field. Age quotas seems to be the most appealing, since, then, the early and late born athletes are given equal opportunities, e.g. for professionalized training. However, this still is a bit arbitrary and not necessarily right, since it might well be that within a particular group of peers, more high potentials are born in the first part of the year, who might then be missed by the selection system. It is, therefore, better to use a performance based selection system that takes account of the performance difference between early and late born peers. This will be the topic of the next subsection.

7.2 Selection systems

Although the previous subsection discussed some of the potential reasons for a RAE to occur, it could be argued that the selection system is what ultimately determines the composition of athletes for a given subgroup (e.g. elite athletes) and, therefore, would be the most important element. This reasoning implicitly assumes that RAEs are the result of the incapability of selection systems to overcome or correctly incorporate the reasons discussed above. While this indeed seems to be the case, the literature that was discussed in section 2 showed that there are more fundamental problems with talent selection, identification and development. A core element within this debate is the discussion of what is responsible for expert performances.

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used to do, might still be seen as elite, since their performances might still show up in the rankings. This is in contrast to, for example, soccer, in which a player can decide to play for a club which is playing in a lower division. Individuals within track & field, thus, have less options in their decision on which level they want to be active, compared to other sports, such as soccer. Although this difference might be important when comparing track & field to other sports, it is of minor importance within this thesis.

Historically, expertise was attributed to innate factors, which is the nature-based view (Galton; 1869, 1874). Nowadays, however, researchers more and more acknowledge the importance of (deliberate) practice (Ericsson *et al.*; 1993) and other environmental factors (Gagné; 2004, 2009). Furthermore, talent is currently seen as multidimensional and dynamic (Simonton, 1999; Abbott & Collins; 2004), instead of statically determined by genetics. The nurture-based view, thus, gained support and made researchers argue that the ease and speed of development is what matters in the prediction of expertise (Gagné; 2004, 2009).

With respect to selection systems in sports, including track & field, this means that the focus should be on an athlete's potential, instead of the current performance. In section 4, in which some background information on track & field within the Netherlands was provided, it was shown that the KNAU is selecting based on current performances already at early ages. Furthermore, the results of the second part of section 6 showed that significant performance differences exist between early and late born peers, which might well represent a physical advantage.[53] Combined, those findings mean that, if we assume that giftedness and talent are uniformly distributed over the year, the performance based selection system discriminates in favor of early born athletes. It also means that some late born high potentials will be lost, which is not only harmful for those individuals (e.g., declined self esteem (Thomson *et al.*; 2001), but is also in contrast to the aims of the KNAU and, thus, from a social point of view unwanted.

A potential solution would be to incorporate the performance differences into the selection system. The estimations of the coefficients could be used in a comparison between early and late born peers, in which the estimation values are added (or subtracted) from actual performances. In this way it is still possible to use the objective performance measures, but after acknowledging the relative age differences. It should be noted that the estimation results as found in this study might be too rough and, thus, should be seen as a starting point. Other ways to find better results will be discussed in the subsection that will cover some limitations and further research.

7.3 Gender differences

Although there has been done a lot of research into the RAE in sports, most of them focused on male participants. For this reason, many researchers have been arguing that more studies should investigate the existence of an RAE in female sports (Musch & Grondin, 2001; Cobley *et al.*, 2009). This will provide insight into the gender differences, which, can be used for gender specific policies for a given sport. However, if it is the aim to draw some general conclusions about the differences

[53] The results in the second part of section 6 also showed a diminishing effect on performance differences when athletes become older. Since this is rather similar to the declining RAE for older athletes, the same reasoning for physical development as formulated in section 7.1 might apply here.

between the genders, the sport under investigation should be rather similar with respect to both males and females. With this condition being satisfied, any difference that is found can be attributed to the fact that the comparison is between males and females, not to some sport specific effect. Such a sport specific effect might, for example, be the availability of sports clubs. In the Netherlands not all professional soccer clubs have a female soccer team, which means that it is not possible for all females to practice soccer without a lot of traveling. This might influence the start and drop out rates. For track & field these differences, in general, do not exist. Therefore, track & field is a sport that can be used for a comparison between genders, while providing insights into a more general perspective.

For both genders an RAE as well as significant performance differences were found. However, the effects were generally stronger for males than for females. Furthermore, the effects tend to diminish when moving up age cohorts for both genders, but this is strongest for females. While for males the effects are present for all age categories, for females the effects are almost completely gone for the adolescent and (though less clearly) senior age categories. Thus, there seems to be a turning point for females after the age of 15 years, which is not observed for males.

Without going into detail on the differences between males and females during puberty, it does seem to be a valid explanation given the moment of the turning point. The main difference is that males tend to develop in a way that is, in general, beneficial for sport performances, while female development is not necessarily better within sports (Malina, Bouchard & Bar-Or; 2004). An example might be that males become stronger, while females only gain some weight. This means that early born males generally keep their relative age advantage during puberty, while early born females might well lose it. Note that early born athletes will, in general, enter puberty earlier than their late born peers.

Although physical development is, of course, an important aspect during puberty, it should be noted that mental development might be as important for sports participation and performances (Vincent & Glamser; 2006). Furthermore, general mental differences between males and females may also account for the different results that were found in section 6. Interesting in this respect are the studies by Gneezy, Niederle & Rustichini (2003) and Gneezy & Rustichini (2004) who investigate the differences in the influence on competitiveness between genders within an experimental design. Gneezy *et al.* (2003) used students that had to solve mazes on a computer and found that, when competitiveness increased by way of a different payment scheme, the performances of males increased while the performances of females remained constant. Gneezy & Rustichini (2004) used 75 boys and 65 girls aged 9-10 years old, which had to run a short distance. The competitiveness was controlled, by using two rounds, in which in the second round competitors knew the other's first round performance. Their main finding was that 'competition improves performances relative to a non-competitive environment for boys, but not for girls' (Gneezy & Rustichini; 2004, p. 379). Their overall conclusion is that males are more competitive than females (Gneezy & Rustichini; 2004). Relating this to the track & field and the results as found before, we might have another explanation for the differences between males and females. Given that males are more competitive, they might drop out of the sport earlier relative to females if they cannot win. Since the late born participants are often the ones that do not win, relatively more late born females will still be active compared to males. More late born athletes will, after development is completed, mean that the distributions will be more uniform. This is what we observed above and is in line with previous literature, (e.g., Baxter-Jones & Helms, 1994; Musch & Grondin, 2001; Vincent & Glamser, 2006) who also argued that the smaller degree of competition in female sports might be an explanation for the differences between the genders that were found.

7.4 Limitations and further research

This thesis corroborates the notion that a RAE within elite Dutch track & field exists. Furthermore, significant performance differences between early and late born peers were found. These results clearly indicate that not all athletes are provided with equal opportunities, which implies that some potential talents are lost (a type I error). It would be interesting to know how large the implication of this imperfection of the system is. Given that only a small number of elite adults are needed within this individualistic sport, the ultimate effect of the imperfection might be small. Unfortunately, the data could not provide insight into this aspect. It should be noted, however, that it is generally difficult to provide evidence of potential talents that were missed by the selection system, since they might have dropped out of the sport at an early age.

Furthermore, the data could also not reveal which factors determine expert performances. We saw that two main contributors exist: innate talent (nature) and practice (nurture). The level of practice was proxied by the 'clubranking' variable. However, this variable was very rough and further research that focuses on the differences in performances should preferably use a different measure. Further research should, then, also use a different structure of the data. Although the sample that was used within this thesis was based on micro data, it would be better to have data on the same individual for multiple years. Such a longitudinal design would make it be possible to control for giftedness or innate factors, insofar they do not change over time (remember e.g. Simonton's (1999) model in which talent is seen as dynamic).[54] To obtain such data, someone should follow a well

[54] Note that there are, of course, individuals that occur in multiple years within the rankings that were used. From those persons it would be possible to obtain in-person developments. However, using this method would have meant that the number of observations would have decreased by even more. This because the same selection procedure as already used to obtain an equal number of athletes per quarter should be used, while not all individuals will be in the rankings for all those years.

balanced group of athletes for many years, which is a costly process. However, as mentioned in section 7.2 it will probably improve the estimation results.[55]

Other improvements to the estimation results, for using them in a comparison between performances, might be achieved by using smaller intervals (e.g. months). It was chosen to use quarter-dummies. This, in fact, creates three extra cut-off dates and again some athletes will be early born (beginning of the quarter) and some athletes will be late born (late in the quarter). In principle, the same hypotheses and expectations (i.e. the same RAE) hold for these quarters as was formulated for the entire age categories. This means that the estimation results as presented in section 6 overestimate the performance difference for the early born athletes and underestimates the performance difference for the late born athletes. Smaller intervals would reduce these over- and underestimations, which subsequently would make it possible to better compare the performances between athletes. However, to be able to use the selection procedure to obtain an equal number of athletes per period, this requires a minimum number of athletes per period, which, given the existence of the RAE, is hard to achieve. Using months instead of quarters does not work when using this sample, especially at early age categories the number of observations will be problematic. A qualitative variable that can have a value for each day of the year might be another solution, but suffers from the fact that it does not allow for different estimations for different periods of the year (i.e. only one coefficient is estimated) which means development is assumed to be constant throughout the year. Based on the principle of a diminishing development of performances, this is incorrect as well.

Again, a different (larger) sample should provide a solution. For this reason the estimation results as presented within this thesis should only be used as a starting point in the comparison of performances. Given the significance and practical relevance of the results, however, other results that are obtained in a better way will probably point in the same direction.

7.5 Other applications

Although this study was based on track & field, this subsection will be used to briefly discuss how the methods and findings relate to other applications. Starting with other sports, two differences are noteworthy to mention. The first is that track & field provides objective performances. As best to the authors' knowledge, this study is the first one to link a RAE to the performance differences between early and late born peers. Furthermore, as mentioned, the estimations of the performance differences can be used in the comparison of the performances between those peers. This, of course, will be possible for all sports in which objective performances

[55] Within such a design it is also possible to monitor personal development, both physical (by measuring) and mental (by questionnaires). The influence of these elements can, then, also be investigated.

are available (which is more common for individualistic sports than for team sports) and, thus, might be a helpful tool to overcome the problems that the selection systems encounter. The second point, which was already extensively discussed in section 7.3, is that we found differences between genders. Track & field is not subject to sport specific factors, such as the availability of sporting clubs. Thus, it seems fair to state that gender differences are indeed caused by the differences between males and females. However, more research should be conducted in this direction. Interesting elements in this respect are the roles of personal development, especially during and after puberty, and competition and competitiveness.

One of the big differences between school systems and sports is that it is mandatory to maintain at school until a certain age, while one is free to drop out of sports whenever one wants. However, in both fields we observe RAEs. For sports this mainly results in a skewed birth date distribution, with an overrepresentation of participants born close after the cut-off date. For school systems, the RAE cannot become visible by an evaluation of birth date distributions, since it is compulsory. Therefore, output measures, such as school performances and wages, are often related to relative age. Some examples of studies that relate school systems to a RAE are Angrist & Krueger (1991), who document a wage premium in the United States for those who are obliged to attend school longer because of compulsory schooling laws; Plug (2001), who documents increased school performances and higher earnings for those born close after the cut-off date in the Netherlands; and Dhuey & Lipscomb (2008), who show that early born kids have a higher probability of becoming a high school leader, which positively affects the rest of their lives. Interestingly, schools use grades, which are objective measures of performance. In this respect, it does look similar to track & field, which would make it possible for potential performance differences to be estimated. These estimations, in turn, can be used to make a better comparison of the performance between early and late born peers. This might not directly lead to an equal wage, but it will give parents and teachers (the ones who have to make decisions for the child) a better picture of the relative performance of a child. This might lead to different decisions, such as to which secondary school someone should go or who should be the next high school leader. Given that some clear differences were found in this study for elite track & field between males and females, it should be recommended that that gender is taken into account when making these decisions.

The previous paragraph made the analogue between school systems and track & field clear. It should, however, be noted that they are also working in an interconnected way. Without going into detail of how this might work, a misinterpretation of the relative performance in track & field (or more general in sports) might have implications for personal wellbeing[56] which, in turn, might have implications for school achievements. Also, the reasoning might work the other way around, in which a misinterpretation of school performances influences the track & field achievements.[57] Although it will be positive for some individuals and negative for others, the allocation of opportunities will be inefficient from a social point of view. Related to track & field, this implies that talent might be lost. For this reason it is important that the performance based selection systems of other domains, such as school systems, also incorporate the performance differences that are the result of the relative age differences.

[56]For example, Thomson *et al.* (2001) document that relative age differences might result in declined self-esteem.

[57] Note that the environment will play an important role in many occasions of these misinterpretations of performances.

8. Conclusion

This study revealed that within elite Dutch track & field, like in many other sports, an RAE exists. For both males and females this implies that not all athletes are given equal opportunities to participate and develop. Besides this being inequitable, it implies that some high potentials are overlooked by the selection system, which implies the system is inefficient and results in an inefficient allocation of athletes. The selection system is too much focused on performances and not able to overcome the problems that were discussed in the text. This incapability of the system might result in the investment of scarce resources in the wrong athletes. Since only a selected group of athletes will exhibit the necessary natural abilities to become an expert performer, it is important that those athletes are supported by their environment. However, the unfortunate ones who are born within the wrong period of the year might never get this support. This would mean a waste of talent, which is not only bad for the athlete in question, but also for the entire sport. It would, therefore, be good if all parents, coaches, athletes and all other people that are involved within the sport, are familiar with the concept of relative age differences and the resulting performance differences. With this knowledge, the selection system could be improved by the incorporation of these performance differences. Estimation results can be used to better compare the current performances, which is especially relevant at early ages. It might well result in a whole different ranking, with a better allocation of opportunities as a consequence. This does not mean it would be good to award the best relative performer with the national championship, since within such a match the best absolute performance should win. However, let us hope that there will be a moment at which everybody knows that the winner might not have been the most skilled, talented or driven athlete.

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Appendix A1

Table A1a: overview of the different disciplines with an indication of the age category

Males		Females	
Discipline	**Age category**	**Discipline**	**Age category**
1000m	C,D	1000m	C,D
100m	A,B,C,S	100m	A,B,S
100m Hurdles	C	100m Hurdles	A,B,S
110m Hurdles	A,B,S	1500m	A,B,C,S
1500m	A,B,C,S	3000m	A,B,S
300m Hurdles	C	300m Hurdles	C
400m	A,B,S	400m	A,B,S
400m Hurdles	A,B,S	400m Hurdles	A,B,S
5000m	A,S	600m	C,D
600m	D	60m	D
800m	A,B,C,S	60m Hurdles	D
80m	D	800m	A,B,S
80m Hurdles	D	80m	C
Discus Throw	A,B,C,D,S	80m Hurdles	C
High Jump	A,B,C,D,S	Discus Throw	A,B,C,D,S
Shot Put	A,B,C,D,S	High Jump	A,B,C,D,S
Pole Vault	A,B,C,S	Shot Put	A,B,C,D,S
Javelin	A,B,C,D,S	Pole Vault	A,B,C,S
Long Jump	A,B,C,D,S	Javelin	A,B,C,D,S
		Long Jump	A,B,C,D,S

The letters in column two and four correspond to the age categories and ages as explained in the text. Furthermore, it should be noted that some disciplines have different rules for different age categories. For the relevant disciplines, these differences can be found in the table below. Some distances logically also belong together, such as 80m and 100m, but these are separately included in table A1a. Finally, it should be noted that no data was available for the 600m males-D for the seasons 2005 and 2006.

Table A1b: overview of the discipline specific different weights or heights

Javelin	**weight / height**	**Javelin**	**weight / height**
Males-D	400 g	Females-D	400 g
Males-C	600 g	Females-C	600 g*
Males-B	700 g	Females-B	600 g
Males-A	800 g	Females-A	600 g
Males-Senior	800 g	Females-Senior	600 g
Shot Put	**weight / height**	**Shot Put**	**weight / height**
Males-D	3 kg	Females-D	2 kg
Males-C	4 kg	Females-C	3 kg
Males-B	5 kg	Females-B	3 kg
Males-A	6 kg	Females-A	4 kg
Males-Senior	7.25 kg	Females-Senior	4 kg

Table A1b continued

Discus Throw	weight / height	Discus Throw	weight / height
Males-D	1 kg	Females-D	750 g
Males-C	1 kg	Females-C	1 kg
Males-B	1.5 kg	Females-B	1 kg
Males-A	1.75 kg	Females-A	1 kg
Males-Senior	2 kg	Females-Senior	1 kg
Hurdles Short	**weight / height**	**Hurdles Short**	**weight / height**
Males-D	76.2 cm	Females-D	76.2 cm
Males-C	84 cm	Females-C	76.2 cm
Males-B	91.4 cm	Females-B	76.2 cm
Males-A	100 cm**	Females-A	84 cm
Males-Senior	106.7 cm	Females-Senior	84 cm
Hurdles Long	**weight / height**	**Hurdles Long**	**weight / height**
Males-D	x	Females-D	x
Males-C	76.2 cm	Females-C	76.2 cm
Males-B	84 cm	Females-B	76.2 cm
Males-A	91.4 cm	Females-A	76.2 cm
Males-Senior	91.4 cm	Females-Senior	76.2 cm

*From 2009 onwards this is 500g

**From 2008 onwards this is 99.1 cm

Appendix A2

Table A2a: distribution of birth dates per quarter for male athletes, distinguished by discipline

Males-D

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	130	79	39	28	276	92.78	0.00	9.73
600m	39	38	14	10	101	28.15	0.00	10.29
80m	141	93	40	22	296	117.70	0.00	14.24
80m Hurdles	129	89	40	22	280	100.66	0.00	12.36
Discus Throw	113	82	45	29	269	63.48	0.00	6.94
High Jump	151	101	54	41	347	86.42	0.00	7.04
Shot Put	126	90	42	26	284	88.06	0.00	10.09
Javelin	115	91	40	27	273	76.23	0.00	9.45
Long Jump	127	85	34	28	274	95.26	0.00	11.69
Total	1,071	748	348	233	2,400	736.56	0.00	9.80

Males-C

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	110	75	39	28	252	65.94	0.00	7.62
100m	135	90	57	22	304	91.50	0.00	8.11
100m Hurdles	131	85	45	23	284	95.44	0.00	10.09
1500m	96	77	44	54	271	24.16	0.00	3.12
300m Hurdles	110	90	43	30	273	63.25	0.00	7.51
800m	112	82	47	35	276	53.01	0.00	5.60
Discus Throw	106	84	54	27	271	52.79	0.00	5.50
High Jump	137	121	60	42	360	70.82	0.00	6.40
Shot Put	113	91	45	27	276	68.99	0.00	8.03
Pole Vault	95	74	61	26	256	39.28	0.00	3.77
Javelin	112	92	40	30	274	69.18	0.00	8.49
Long Jump	124	89	39	27	279	87.27	0.00	10.42
Total	1,381	1,050	574	371	3,376	743.41	0.00	6.62

Males-B

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	110	84	66	30	290	46.72	0.00	4.08
110m Hurdles	105	81	60	30	276	44.09	0.00	4.27
1500m	84	56	54	45	239	14.27	0.00	2.00
400m	98	88	48	29	263	48.68	0.00	5.84
400m Hurdles	76	73	32	38	219	28.91	0.00	4.53
800m	88	71	48	37	244	25.80	0.00	3.50
Discus Throw	86	80	47	30	243	35.27	0.00	4.65
High Jump	96	67	50	53	266	19.92	0.00	2.50
Shot Put	80	90	56	29	255	34.84	0.00	4.00
Pole Vault	79	76	58	35	248	19.84	0.00	2.78
Javelin	102	89	38	29	258	61.53	0.00	8.13
Long Jump	90	71	51	33	245	29.79	0.00	3.67
Total	1,094	926	608	418	3,046	366.61	0.00	3.88

Males-A

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	124	103	82	56	365	27.82	0.00	2.71
110m Hurdles	120	85	57	64	326	29.46	0.00	2.87
1500m	104	87	82	76	349	4.98	0.17	1.46
400m	129	119	75	62	385	33.40	0.00	3.28
400m Hurdles	87	76	52	50	265	14.98	0.00	2.55
5000m	51	65	61	65	242	2.17	0.54	0.85
800m	113	107	80	71	371	13.46	0.00	2.12
Discus Throw	74	77	45	41	237	18.04	0.00	3.08
High Jump	90	75	39	48	252	26.57	0.00	3.60
Shot Put	90	82	59	50	281	15.16	0.00	2.49
Pole Vault	76	80	61	45	262	11.62	0.01	2.17
Javelin	108	103	66	54	331	26.04	0.00	3.09
Long Jump	108	96	61	47	312	31.72	0.00	3.57
Total	1,274	1,155	820	729	3,978	205.95	0.00	2.46

Males-Senior

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	242	227	238	170	877	15.30	0.00	1.32
110m Hurdles	258	230	160	127	775	56.96	0.00	2.89
1500m	207	216	169	228	820	9.51	0.02	1.14
400m	230	227	207	162	826	14.30	0.00	1.53
400m Hurdles	241	183	159	109	692	52.12	0.00	2.50
5000m	138	183	188	178	687	9.13	0.03	0.77
800m	234	189	175	212	810	9.98	0.02	1.19
Discus Throw	321	218	243	197	979	36.01	0.00	1.50
High Jump	221	170	95	87	573	85.53	0.00	4.62
Shot Put	333	233	243	171	980	54.56	0.00	1.87
Pole Vault	227	208	126	111	672	60.08	0.00	3.37
Javelin	281	248	143	119	791	94.34	0.00	4.08
Long Jump	230	168	121	142	661	40.54	0.00	2.29
Total	3,163	2,700	2,267	2,013	10,143	302.05	0.00	1.88

Table A2b: distribution of birth dates per quarter for female athletes, distinguished by discipline

Females-D

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	88	72	67	36	263	21.61	0.00	2.41
600m	89	87	68	29	273	34.03	0.00	3.29
60m	114	82	54	38	288	46.44	0.00	4.54
60m Hurdles	106	94	50	25	275	62.41	0.00	7.11
Discus Throw	104	87	53	30	274	48.54	0.00	5.30
High Jump	184	142	90	47	463	92.76	0.00	5.66
Shot Put	110	86	51	19	266	71.71	0.00	7.84
Javelin	107	88	40	36	271	55.04	0.00	6.58
Long Jump	105	102	43	27	277	69.67	0.00	8.74
Total	1,007	840	516	287	2,650	471.92	0.00	5.29

Females-C

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	57	53	56	36	202	5.72	0.13	1.43
1500m	62	39	58	40	199	8.62	0.03	1.06
300m Hurdles	86	86	48	42	262	25.94	0.00	3.65
600m	70	72	55	45	242	8.15	0.04	2.02
80m	93	97	50	58	298	23.10	0.00	3.09
80m Hurdles	77	94	65	42	278	20.62	0.00	2.55
Discus Throw	92	86	55	33	266	34.36	0.00	4.09
High Jump	112	116	83	61	372	21.66	0.00	2.51
Shot Put	93	87	54	31	265	38.32	0.00	4.48
Pole Vault	22	31	39	26	118	5.46	0.14	0.66
Javelin	103	90	37	38	268	53.22	0.00	6.62
Long Jump	70	84	49	45	248	16.23	0.00	2.68
Total	937	935	649	497	3,018	189.96	0.00	2.67

Females-B

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	54	66	53	50	223	2.67	0.45	1.36
100m Hurdles	53	73	70	44	240	9.57	0.02	1.22
1500m	55	44	41	39	179	3.41	0.33	1.53
3000m	43	19	32	31	125	9.24	0.03	0.97
400m	42	51	64	42	199	6.53	0.09	0.77
400m Hurdles	52	47	38	52	189	2.77	0.43	1.21
800m	49	46	54	41	190	1.87	0.60	1.00
Discus Throw	47	59	33	27	166	14.92	0.00	3.12
High Jump	48	80	48	35	211	20.91	0.00	2.38
Shot Put	63	58	42	30	193	14.19	0.00	2.82
Pole Vault	32	28	39	29	128	2.31	0.51	0.78
Javelin	67	53	30	30	180	22.18	0.00	4.00
Long Jump	54	59	46	39	198	4.71	0.19	1.77
Total	659	683	590	489	2,421	37.47	0.00	1.55

Females-A

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	56	68	55	55	237	1.80	0.61	1.20
100m Hurdles	45	80	56	43	224	15.46	0.00	1.59
1500m	53	38	41	60	192	6.63	0.08	0.81
3000m	40	26	40	41	147	4.21	0.24	0.66
400m	42	51	54	54	201	1.93	0.59	0.74
400m Hurdles	45	51	43	42	181	1.08	0.78	1.28
800m	54	47	54	49	204	0.75	0.86	0.96
Discus Throw	46	60	30	46	182	9.91	0.02	1.95
High Jump	33	54	38	36	161	6.58	0.09	1.38
Shot Put	75	80	61	54	270	6.47	0.09	1.82
Pole Vault	35	21	21	21	98	6.00	0.11	1.78
Javelin	57	73	40	45	215	12.03	0.01	2.34
Long Jump	38	56	54	38	186	6.26	0.10	1.04
Total	619	706	590	585	2,498	14.96	0.00	1.27

Females-Senior

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	68	101	60	109	338	20.65	0.00	1.00
100m Hurdles	98	122	49	64	333	39.19	0.00	3.79
1500m	89	99	102	64	354	10.09	0.02	1.28
3000m	84	103	122	112	421	7.44	0.06	0.64
400m	81	100	74	70	325	6.53	0.09	1.58
400m Hurdles	97	102	53	48	300	32.35	0.00	3.88
800m	83	96	96	61	336	9.74	0.02	1.30
Discus Throw	115	118	46	84	363	37.23	0.00	3.21
High Jump	64	111	60	51	286	30.34	0.00	2.49
Shot Put	108	122	60	93	383	22.19	0.00	2.26
Pole Vault	114	72	80	25	291	55.46	0.00	3.14
Javelin	72	98	78	46	294	18.76	0.00	1.88
Long Jump	70	80	87	72	309	2.37	0.50	0.89
Total	1,143	1,324	967	899	4,333	100.62	0.00	1.75

Table A2c: distribution of birth dates per quarter for male athletes, distinguished by season

Males-D

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	110	76	24	16	226	105.12	0.00	21.62
2001	88	61	32	31	212	41.77	0.00	5.59
2002	95	76	22	20	213	81.55	0.00	16.58
2003	87	80	40	31	238	39.82	0.00	5.53
2004	105	87	17	16	225	115.25	0.00	33.85
2005	109	62	17	14	202	118.99	0.00	30.43
2006	100	61	29	13	203	87.27	0.00	14.69
2007	99	61	35	22	217	63.76	0.00	7.88
2008	95	66	45	21	227	52.24	0.00	5.95
2009	89	65	41	17	212	54.34	0.00	7.05
2010	94	53	46	32	225	37.84	0.00	3.55
Total	1,071	748	348	233	2,400	736.56	0.00	9.80

Males-C

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	146	66	57	38	307	88.64	0.00	4.98
2001	149	76	50	22	297	119.98	0.00	9.77
2002	139	99	53	28	319	91.22	0.00	8.63
2003	125	86	60	39	310	53.12	0.00	4.54
2004	113	99	48	48	308	44.96	0.00	4.88
2005	91	110	65	43	309	33.46	0.00	3.46
2006	121	125	30	27	303	118.06	0.00	18.63
2007	138	96	50	32	316	86.33	0.00	8.14
2008	128	97	53	24	302	84.46	0.00	8.54
2009	120	96	58	36	310	54.85	0.00	5.28
2010	111	100	50	34	295	57.23	0.00	6.31
Total	1,381	1,050	574	371	3,376	743.41	0.00	6.62

Males-B

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	76	73	57	36	242	16.68	0.00	2.57
2001	98	59	49	37	243	34.45	0.00	3.33
2002	105	65	64	31	265	41.52	0.00	3.20
2003	116	91	68	21	296	66.19	0.00	5.41
2004	107	84	57	37	285	39.53	0.00	4.13
2005	88	88	65	41	282	21.46	0.00	2.76
2006	79	90	53	55	277	14.34	0.00	2.45
2007	96	95	56	41	288	32.25	0.00	3.88
2008	109	93	42	42	286	50.48	0.00	5.78
2009	119	90	40	41	290	62.30	0.00	6.66
2010	101	98	57	36	292	41.56	0.00	4.58
Total	1,094	926	608	418	3,046	366.61	0.00	3.88

Males-A

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	157	115	54	46	372	89.35	0.00	7.40
2001	114	97	66	55	332	26.87	0.00	3.04
2002	97	93	69	69	328	8.34	0.04	1.90
2003	111	71	82	79	343	10.67	0.01	1.28
2004	138	83	76	68	365	33.17	0.00	2.36
2005	129	124	76	50	379	46.26	0.00	4.03
2006	147	139	80	52	418	60.79	0.00	4.69
2007	92	120	67	72	351	19.79	0.00	2.33
2008	85	99	89	70	343	5.07	0.17	1.34
2009	97	103	82	93	375	2.50	0.47	1.31
2010	107	111	79	75	372	11.18	0.01	2.00
Total	1,274	1,155	820	729	3,978	205.95	0.00	2.46

Males-Senior

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	256	262	233	197	948	10.98	0.01	1.45
2001	262	262	223	201	948	11.57	0.01	1.53
2002	286	259	238	170	953	30.93	0.00	1.78
2003	291	246	219	159	915	39.92	0.00	2.02
2004	274	220	224	173	891	22.94	0.00	1.55
2005	267	210	219	196	892	12.78	0.01	1.32
2006	285	190	210	187	872	28.89	0.00	1.43
2007	319	253	188	182	942	52.64	0.00	2.39
2008	325	268	173	174	940	71.29	0.00	2.92
2009	311	253	172	193	929	50.82	0.00	2.39
2010	287	277	168	181	913	51.22	0.00	2.61
Total	3,163	2,700	2,267	2,013	10,143	302.05	0.00	1.88

Table A2d: distribution of birth dates per quarter for female athletes, distinguished by season

Females-D

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	72	73	53	32	230	19.50	0.00	2.91
2001	95	75	44	22	236	53.32	0.00	6.63
2002	86	86	49	20	241	51.00	0.00	6.21
2003	67	88	59	32	246	26.16	0.00	2.90
2004	78	85	31	34	228	42.63	0.00	6.29
2005	73	91	36	35	235	39.57	0.00	5.34
2006	104	68	61	16	249	62.92	0.00	4.99
2007	118	69	46	20	253	82.19	0.00	8.03
2008	96	72	47	26	241	45.89	0.00	5.30
2009	119	62	40	22	243	87.68	0.00	8.52
2010	99	71	50	28	248	44.35	0.00	4.75
Total	1,007	840	516	287	2,650	471.92	0.00	5.29

Females-C

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	57	93	57	57	264	14.73	0.00	1.73
2001	75	80	58	53	266	7.65	0.05	1.95
2002	84	81	55	45	265	16.77	0.00	2.72
2003	83	96	58	44	281	23.70	0.00	3.08
2004	77	112	62	45	296	32.95	0.00	3.12
2005	68	105	62	53	288	21.75	0.00	2.26
2006	77	79	56	49	261	10.37	0.02	2.21
2007	90	84	69	40	283	21.13	0.00	2.55
2008	102	75	61	23	261	49.79	0.00	4.44
2009	120	69	53	42	284	50.28	0.00	3.96
2010	104	61	58	46	269	28.65	0.00	2.52
Total	937	935	649	497	3,018	189.96	0.00	2.67

Females-B

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	63	45	33	33	174	13.86	0.00	2.68
2001	59	60	41	49	209	4.65	0.20	1.75
2002	51	76	53	59	239	6.47	0.09	1.29
2003	54	56	45	43	198	2.53	0.47	1.56
2004	63	63	49	35	210	10.27	0.02	2.25
2005	51	72	44	38	205	12.85	0.00	2.25
2006	43	74	69	59	245	9.16	0.03	0.84
2007	45	63	67	57	232	4.76	0.19	0.76
2008	57	61	58	40	216	5.00	0.17	1.45
2009	70	61	66	45	242	5.97	0.11	1.39
2010	103	52	65	31	251	43.80	0.00	2.61
Total	659	683	590	489	2,421	37.47	0.00	1.55

Females-A

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	66	47	46	67	226	7.10	0.07	1.00
2001	60	63	44	57	224	3.75	0.29	1.48
2002	64	57	30	38	189	16.06	0.00	3.17
2003	55	79	40	58	232	13.34	0.00	1.87
2004	49	80	51	60	240	10.03	0.02	1.35
2005	60	47	56	43	206	3.59	0.31	1.17
2006	63	66	53	44	226	5.33	0.15	1.77
2007	50	78	60	47	235	9.99	0.02	1.43
2008	53	68	75	60	256	4.28	0.23	0.80
2009	51	67	74	56	248	5.26	0.15	0.82
2010	48	53	61	54	216	1.59	0.66	0.77
Total	619	705	590	584	2,498	14.96	0.00	1.27

Females-Senior

Season / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
2000	139	122	88	73	422	26.13	0.00	2.63
2001	122	121	91	72	406	17.55	0.00	2.22
2002	118	122	91	82	413	11.34	0.01	1.92
2003	115	118	91	74	398	13.12	0.00	1.99
2004	106	105	79	86	376	5.89	0.12	1.64
2005	92	104	85	96	377	2.00	0.57	1.17
2006	90	131	86	85	392	14.96	0.00	1.67
2007	92	130	89	86	397	12.88	0.00	1.61
2008	88	127	88	75	378	16.10	0.00	1.74
2009	93	121	90	80	384	9.65	0.02	1.58
2010	88	123	89	90	390	8.91	0.03	1.39
Total	1,143	1,324	967	899	4,333	100.62	0.00	1.75

Table A2e: distribution of birth dates per quarter for male athletes, distinguished by discipline and year indicator

Males-D 1st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	24	14	7	1	46	25.48	0.00	22.56
600m	3	4	1	0	8	5.00	0.17	49.00
80m	12	7	2	0	21	16.52	0.00	90.25
80m Hurdles	17	4	4	1	26	23.54	0.00	17.64
Discus Throw	13	7	3	4	27	9.00	0.03	8.16
High Jump	24	10	4	2	40	29.60	0.00	32.11
Shot Put	10	8	3	2	23	7.78	0.05	12.96
Javelin	15	8	3	2	28	15.14	0.00	21.16
Long Jump	22	10	4	2	38	25.58	0.00	28.44
Total	140	72	31	14	257	146.75	0.00	22.19

Males-D 2dn year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	106	65	32	27	230	69.37	0.00	8.40
600m	36	34	13	10	93	24.03	0.00	9.26
80m	129	86	38	22	275	102.67	0.00	12.84
80m Hurdles	112	85	36	21	254	84.68	0.00	11.94
Discus Throw	100	75	42	25	242	55.75	0.00	6.82
High Jump	127	91	50	39	307	63.44	0.00	6.00
Shot Put	116	82	39	24	261	80.41	0.00	9.88
Javelin	100	83	37	25	245	63.29	0.00	8.71
Long Jump	105	75	30	26	236	72.92	0.00	10.33
Total	931	676	317	219	2,143	604.90	0.00	8.99

Males-C 1st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	29	14	8	5	56	24.43	0.00	10.94
100m	21	17	8	1	47	20.66	0.00	17.83
100m Hurdles	29	20	5	2	56	34.71	0.00	49.00
1500m	26	15	7	14	62	11.94	0.01	3.81
300m Hurdles	36	28	10	4	78	34.62	0.00	20.90
800m	30	17	7	4	58	28.48	0.00	18.26
Discus Throw	25	13	6	4	48	22.50	0.00	14.44
High Jump	30	20	11	3	64	25.38	0.00	12.76
Shot Put	19	16	5	4	44	15.82	0.00	15.12
Pole Vault	25	24	15	8	72	10.78	0.01	4.54
Javelin	25	16	5	4	50	23.76	0.00	20.75
Long Jump	19	14	4	2	39	20.18	0.00	30.25
Total	314	214	91	55	674	250.02	0.00	13.08

Males-C 2nd year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	81	61	31	23	196	44.24	0.00	6.91
100m	114	73	49	21	257	72.45	0.00	7.14
100m Hurdles	102	65	40	21	228	64.46	0.00	7.50
1500m	70	62	37	40	209	15.17	0.00	2.94
300m Hurdles	74	62	33	26	195	32.38	0.00	5.31
800m	82	65	40	31	218	29.89	0.00	4.29
Discus Throw	81	71	48	23	223	35.92	0.00	4.58
High Jump	107	101	49	39	296	49.57	0.00	5.59
Shot Put	94	75	40	23	232	54.03	0.00	7.20
Pole Vault	70	50	46	18	184	29.91	0.00	3.52
Javelin	87	76	35	26	224	48.25	0.00	7.14
Long Jump	105	75	35	25	240	68.33	0.00	9.00
Total	1,067	836	483	316	2,702	511.22	0.00	5.67

Males-B 1st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	44	25	23	9	101	24.58	0.00	4.65
110m Hurdles	44	35	26	9	114	23.47	0.00	5.09
1500m	34	20	20	16	90	8.31	0.04	2.25
400m	36	30	12	10	88	22.91	0.00	9.00
400m Hurdles	36	33	11	14	94	20.98	0.00	7.62
800m	32	22	12	9	75	17.43	0.00	6.61
Discus Throw	37	32	14	12	95	20.07	0.00	7.04
High Jump	35	28	19	21	103	6.17	0.10	2.48
Shot Put	26	37	21	12	96	13.58	0.00	3.64
Pole Vault	32	31	17	9	89	16.84	0.00	5.87
Javelin	40	36	11	11	98	30.08	0.00	11.93
Long Jump	42	30	17	9	98	25.84	0.00	7.67
Total	438	359	203	141	1,141	197.53	0.00	5.37

Table A2e continued

Males-B 2st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	66	59	43	21	189	25.33	0.00	3.81
110m Hurdles	61	46	34	21	162	21.56	0.00	3.78
1500m	50	36	34	29	149	6.52	0.09	1.86
400m	62	58	36	19	175	27.63	0.00	4.76
400m Hurdles	40	40	21	24	125	9.94	0.02	3.16
800m	56	49	36	28	169	11.28	0.01	2.69
Discus Throw	49	48	33	18	148	17.35	0.00	3.62
High Jump	61	39	31	32	163	14.35	0.00	2.52
Shot Put	54	53	35	17	159	23.11	0.00	4.23
Pole Vault	47	45	41	26	159	6.81	0.08	1.89
Javelin	62	53	27	18	160	32.65	0.00	6.53
Long Jump	48	41	34	24	147	8.56	0.04	2.35
Total	656	567	405	277	1,905	179.16	0.00	3.22

Males-A 1st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	59	47	40	27	173	12.41	0.01	2.50
110m Hurdles	65	43	29	34	171	17.80	0.00	2.94
1500m	54	44	37	34	169	5.60	0.13	1.91
400m	62	52	36	26	176	17.64	0.00	3.38
400m Hurdles	45	41	23	29	138	9.13	0.03	2.74
5000m	26	31	27	30	114	0.60	0.90	1.00
800m	59	49	38	34	180	8.49	0.04	2.25
Discus Throw	35	35	19	20	109	8.83	0.03	3.22
High Jump	48	35	21	24	128	14.06	0.00	3.40
Shot Put	44	38	25	21	128	10.94	0.01	3.18
Pole Vault	40	40	34	26	140	3.77	0.29	1.78
Javelin	50	54	33	22	159	16.82	0.00	3.58
Long Jump	49	54	31	22	156	17.38	0.00	3.78
Total	636	563	393	349	1,941	115.08	0.00	2.61

Males-A 2nd year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	65	56	42	29	192	15.63	0.00	2.90
110m Hurdles	55	42	28	30	155	12.05	0.01	2.80
1500m	50	43	45	42	180	0.84	0.84	1.14
400m	67	67	39	36	209	16.74	0.00	3.19
400m Hurdles	42	35	29	21	127	7.52	0.06	2.37
5000m	25	34	34	35	128	2.06	0.56	0.73
800m	54	58	42	37	191	6.13	0.11	2.01
Discus Throw	39	42	26	21	128	9.56	0.02	2.97
High Jump	42	40	18	24	124	13.55	0.00	3.81
Shot Put	46	44	34	29	153	5.14	0.16	2.04
Pole Vault	36	40	27	19	122	8.69	0.03	2.73
Javelin	58	49	33	32	172	11.21	0.01	2.71
Long Jump	59	42	30	25	156	17.59	0.00	3.37
Total	638	592	427	380	2,037	92.09	0.00	2.32

Males-Senior

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	242	227	238	170	877	15.30	0.00	1.32
110m Hurdles	258	230	160	127	775	56.96	0.00	2.89
1500m	207	216	169	228	820	9.51	0.02	1.14
400m	230	227	207	162	826	14.30	0.00	1.53
400m Hurdles	241	183	159	109	692	52.12	0.00	2.50
5000m	138	183	188	178	687	9.13	0.03	0.77
800m	234	189	175	212	810	9.98	0.02	1.19
Discus Throw	321	218	243	197	979	36.01	0.00	1.50
High Jump	221	170	95	87	573	85.53	0.00	4.62
Shot Put	333	233	243	171	980	54.56	0.00	1.87
Pole Vault	227	208	126	111	672	60.08	0.00	3.37
Javelin	281	248	143	119	791	94.34	0.00	4.08
Long Jump	230	168	121	142	661	40.54	0.00	2.29
Total	3,163	2,700	2,267	2,013	10,143	302.05	0.00	1.88

Table A2f: distribution of birth dates per quarter for male athletes, distinguished by discipline and year indicator

Females-D 1st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	23	22	24	10	79	6.52	0.09	1.75
600m	19	24	13	7	63	10.33	0.02	4.62
60m	21	15	8	8	52	9.08	0.03	5.06
60m Hurdles	15	18	5	4	42	14.19	0.00	13.44
Discus Throw	22	20	7	4	53	18.62	0.00	14.58
High Jump	47	32	19	7	105	33.78	0.00	9.23
Shot Put	12	17	5	2	36	15.33	0.00	17.16
Javelin	22	14	5	2	43	22.95	0.00	26.45
Long Jump	25	14	4	5	48	23.83	0.00	18.78
Total	206	176	90	49	521	123.25	0.00	7.55

Females-D 2nd year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	65	50	43	26	184	17.09	0.00	2.78
600m	70	63	55	22	210	25.77	0.00	2.98
60m	93	67	46	30	236	37.80	0.00	4.43
60m Hurdles	91	76	45	21	233	50.66	0.00	6.40
Discus Throw	82	67	46	26	221	32.48	0.00	4.28
High Jump	137	110	71	40	358	61.11	0.00	4.95
Shot Put	98	69	46	17	230	61.65	0.00	7.03
Javelin	85	74	35	34	228	36.60	0.00	5.31
Long Jump	80	88	39	22	229	53.08	0.00	7.59
Total	801	664	426	238	2,129	352.20	0.00	4.87

Females-C 1st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	26	21	20	16	83	2.45	0.49	1.70
1500m	28	15	22	22	87	3.90	0.27	0.96
300m Hurdles	32	28	20	11	91	11.37	0.01	3.75
600m	33	31	20	15	99	9.08	0.03	3.34
80m	33	34	16	25	108	7.78	0.05	2.67
80m Hurdles	30	29	19	11	89	10.91	0.01	3.87
Discus Throw	36	33	22	12	103	14.01	0.00	4.12
High Jump	52	37	28	17	134	19.61	0.00	3.91
Shot Put	33	26	18	8	85	16.32	0.00	5.15
Pole Vault	8	15	18	8	49	6.27	0.10	0.78
Javelin	36	29	11	11	87	22.38	0.00	8.73
Long Jump	28	30	18	17	93	5.80	0.12	2.75
Total	375	328	232	173	1,108	90.42	0.00	3.01

Females-C 2nd year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
1000m	31	32	36	20	119	4.73	0.19	1.27
1500m	34	24	36	18	112	7.71	0.05	1.15
300m Hurdles	54	58	28	31	171	16.72	0.00	3.60
600m	37	41	35	30	143	1.76	0.62	1.44
80m	60	63	34	33	190	16.61	0.00	3.37
80m Hurdles	47	65	46	31	189	12.29	0.01	2.12
Discus Throw	56	53	33	21	163	20.44	0.00	4.07
High Jump	60	79	55	44	238	10.77	0.01	1.97
Shot Put	60	61	36	23	180	23.24	0.00	4.21
Pole Vault	14	16	21	18	69	1.55	0.67	0.59
Javelin	67	61	26	27	181	31.49	0.00	5.83
Long Jump	42	54	31	28	155	10.81	0.01	2.65
Total	562	607	417	324	1,910	107.08	0.00	2.49

Females-B 1st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	27	30	27	23	107	0.93	0.82	1.30
100m Hurdles	27	33	38	21	119	5.47	0.14	1.03
1500m	26	24	22	18	90	1.56	0.67	1.56
3000m	20	10	14	9	53	5.64	0.13	1.70
400m	18	24	28	22	92	2.26	0.52	0.71
400m Hurdles	26	18	21	28	93	2.70	0.44	0.81
800m	20	25	30	17	92	4.26	0.23	0.92
Discus Throw	22	29	16	8	75	12.73	0.01	4.52
High Jump	22	36	26	19	103	6.40	0.09	1.66
Shot Put	28	27	20	11	86	8.60	0.04	3.15
Pole Vault	13	15	20	13	61	2.15	0.54	0.72
Javelin	33	26	10	11	80	19.30	0.00	7.89
Long Jump	28	31	22	20	101	3.12	0.37	1.97
Total	310	328	294	220	1,152	23.42	0.00	1.54

Table A2f continued

Females-B 2nd year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	27	36	26	27	116	2.28	0.52	1.41
100m Hurdles	26	40	32	23	121	5.58	0.13	1.44
1500m	29	20	19	21	89	2.82	0.42	1.50
3000m	23	9	18	22	72	6.78	0.08	0.64
400m	24	27	36	20	107	5.19	0.16	0.83
400m Hurdles	26	29	17	24	96	3.25	0.35	1.80
800m	29	21	24	24	98	1.35	0.72	1.09
Discus Throw	25	30	17	19	91	4.60	0.20	2.33
High Jump	26	44	22	16	108	16.15	0.00	3.39
Shot Put	35	31	22	19	107	6.31	0.10	2.59
Pole Vault	19	13	19	16	67	1.48	0.69	0.84
Javelin	34	27	20	19	100	5.84	0.12	2.45
Long Jump	26	28	24	19	97	1.85	0.61	1.58
Total	349	355	296	269	1,269	16.43	0.00	1.55

Females-A 1st year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	29	32	28	28	117	0.37	0.95	1.19
100m Hurdles	24	42	26	23	115	8.30	0.04	1.81
1500m	26	22	20	34	102	4.51	0.21	0.79
3000m	23	12	20	21	76	3.68	0.30	0.73
400m	22	28	26	30	106	1.32	0.72	0.80
400m Hurdles	25	26	29	27	107	0.33	0.95	0.83
800m	26	26	26	28	106	0.11	0.99	0.93
Discus Throw	24	28	16	19	87	3.90	0.27	2.21
High Jump	16	31	20	17	84	6.76	0.08	1.61
Shot Put	41	44	28	30	143	5.28	0.15	2.15
Pole Vault	21	10	12	12	55	5.29	0.15	1.67
Javelin	32	41	19	25	117	9.19	0.03	2.75
Long Jump	23	29	27	21	100	1.60	0.66	1.17
Total	332	371	297	315	1,315	9.10	0.03	1.32

Females-A 2nd year

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	27	36	30	27	120	1.80	0.61	1.22
100m Hurdles	21	38	30	20	109	7.88	0.05	1.39
1500m	27	16	21	26	90	3.42	0.33	0.84
3000m	17	14	20	20	71	1.39	0.71	0.60
400m	20	23	28	24	95	1.38	0.71	0.68
400m Hurdles	20	25	14	15	74	4.16	0.24	2.41
800m	28	21	28	21	98	2.00	0.57	1.00
Discus Throw	22	32	14	27	95	7.44	0.06	1.73
High Jump	17	23	18	19	77	1.08	0.78	1.17
Shot Put	34	36	33	24	127	2.67	0.45	1.51
Pole Vault	14	11	9	9	43	1.56	0.67	1.93
Javelin	25	32	21	20	98	3.63	0.30	1.93
Long Jump	15	27	27	17	86	5.72	0.13	0.91
Total	287	334	293	269	1,183	7.65	0.05	1.22

Females-Senior

Discipline / Quarter	Q1	Q2	Q3	Q4	*Total*	χ^2	p-value	OR Q1Q2 vs. Q3Q4
100m	68	101	60	109	338	20.65	0.00	1.00
100m Hurdles	98	122	49	64	333	39.19	0.00	3.79
1500m	89	99	102	64	354	10.09	0.02	1.28
3000m	84	103	122	112	421	7.44	0.06	0.64
400m	81	100	74	70	325	6.53	0.09	1.58
400m Hurdles	97	102	53	48	300	32.35	0.00	3.88
800m	83	96	96	61	336	9.74	0.02	1.30
Discus Throw	115	118	46	84	363	37.23	0.00	3.21
High Jump	64	111	60	51	286	30.34	0.00	2.49
Shot Put	108	122	60	93	383	22.19	0.00	2.26
Pole Vault	114	72	80	25	291	55.46	0.00	3.14
Javelin	72	98	78	46	294	18.76	0.00	1.88
Long Jump	70	80	87	72	309	2.37	0.50	0.89
Total	1143	1324	967	899	4,333	100.62	0.00	1.75

Appendix A3

Table A3a: summary statistics for the selected disciplines for male athletes

Long Jump

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	274	5.03	0.25	4.71	6.92
Males-C	279	5.88	0.23	5.55	6.94
Males-B	245	6.39	0.24	6.08	7.28
Males-A	312	6.53	0.28	6.15	7.38
Males-Senior	661	6.83	0.30	6.40	7.90

Javelin (D=400g; C=600g; B=700g; A, Senior=800g)

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	273	3.78	3.33	33.73	50.47
Males-C	274	4.58	3.88	40.72	64.25
Males-B	258	5.15	4.67	45.76	70.94
Males-A	331	5.03	5.60	44.00	79.59
Males-Senior	791	5.51	6.01	48.00	78.22

Pole Vault

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-C	256	2.76	0.41	2.20	4.00
Males-B	248	3.65	0.34	3.10	5.03
Males-A	262	3.82	0.42	3.20	5.21
Males-Senior	672	4.20	0.50	3.50	5.81

Shot Put (D=3kg; C=4kg; B=5kg; A=6kg; Senior=7.25kg)

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	284	11.46	0.92	10.24	15.69
Males-C	276	13.32	0.99	12.05	16.96
Males-B	255	13.85	1.11	12.42	18.88
Males-A	281	13.27	1.44	11.80	20.85
Males-Senior	980	13.64	1.57	12.00	21.62

High Jump

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	354	1.55	0.05	1.50	1.75
Males-C	360	1.75	0.06	1.70	2.00
Males-B	266	1.86	0.06	1.80	2.06
Males-A	252	1.90	0.06	1.81	2.15
Males-Senior	573	1.96	0.08	1.86	2.29

Discus Throw (D=1kg; C=1kg; B=1,5kg; A=1.75kg; Senior=2kg)

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	269	28.72	3.29	24.36	42.49
Males-C	271	41.85	3.73	34.71	57.10
Males-B	243	41.08	4.10	36.00	58.54
Males-A	237	39.88	4.89	33.86	62.37
Males-Senior	979	42.00	5.45	36.03	67.63

Hurdles Short (D=80m & 76.2cm height; C=100m & 84cm height; B=110m & 91.4cm height; A=110m & 100cm height; Senior= 110m & 106.7cm height)*

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	280	13.04	0.44	11.68	13.79
Males-C	284	14.60	0.42	13.22	15.27
Males-B	276	15.39	0.54	13.98	16.38
Males-A	326	15.77	0.74	13.77	16.94
Males-Senior	775	15.60	0.78	13.25	16.83

Sprint (D=80m; C, B, A, Senior=100m)

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	296	10.52	0.26	9.13	10.89
Males-C	304	11.89	0.22	11.06	12.27
Males-B	290	11.39	0.22	10.55	11.72
Males-A	365	11.24	0.27	10.26	11.61
Males-Senior	877	10.97	0.28	9.76	11.33

Middle Distance (D=600m; C, B, A, Senior=800m)

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	101	100.69	3.31	89.86	104.90
Males-C	285	125.68	6.14	90.70	133.58
Males-B	244	119.40	2.43	112.18	123.57
Males-A	371	116.77	2.79	105.64	121.34
Males-Senior	810	113.58	2.78	103.45	117.91

Hurdles Long (C=300m & 76.2cm height; B=400m & 84cm height; A, Senior=400m & 91.4cm height)

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-C	273	44.30	1.94	38.92	48.97
Males-B	219	59.95	2.75	52.41	65.44
Males-A	265	59.58	3.34	51.08	65.85
Males-Senior	692	56.88	2.68	48.95	61.16

Long Distance (D, C= 1000m; B, A, Senior= 1500m)

Age category	*n*	*mean*	*SD*	*min*	*max*
Males-D	278	181.92	4.57	163.27	189.60
Males-C	523	220.90	50.43	156.53	284.29
Males-B	307	230.73	38.94	147.88	263.46
Males-A	437	227.69	37.19	140.38	257.98
Males-Senior	942	224.00	30.29	137.01	244.73

Table A3a continued

400m					
Age category	*n*	*mean*	*SD*	*min*	*max*
Males-B	263	51.70	1.10	48.29	53.78
Males-A	385	50.68	1.16	47.09	52.51
Males-Senior	826	49.45	1.12	46.02	51.03
5000m					
Age category	*n*	*mean*	*SD*	*min*	*max*
Males-A	242	954.593	36.866	830.430	1016.700
Males-Senior	687	886.527	25.916	793.060	919.790

*From 2008 onwards the height for Males-A changed to 99.1 cm. Although this makes it easier to perform better, separate summary statistics per season did not reveal any differences and, therefore, this change is not taken into account any further.

Table A3b: summary statistics for the selected disciplines for female athletes

Long Jump					
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	278	4.75	0.17	4.50	5.26
Females-C	248	5.16	0.16	4.93	5.79
Females-B	198	5.37	0.19	5.07	6.11
Females-A	186	5.42	0.24	5.09	6.35
Females-Senior	309	5.63	0.29	5.26	6.64
Javelin	(D=400g; C, B, A, Senior=600g)*				
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	271	30.41	3.10	26.19	48.82
Females-C	268	33.14	3.19	28.49	45.50
Females-B	180	36.37	3.52	32.27	51.38
Females-A	215	36.70	4.65	30.97	53.80
Females-Senior	294	40.99	4.94	34.44	59.27
Pole Vault					
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-C	118	2.44	0.40	1.90	3.50
Females-B	128	2.67	0.45	2.00	4.00
Females-A	98	2.75	0.51	2.10	4.20
Females-Senior	291	3.02	0.50	2.20	4.31
Shot Put	(D=2kg; C, B=3kg; A, Senior=4kg)				
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	271	11.95	1.01	10.70	18.56
Females-C	265	11.69	1.07	10.37	17.48
Females-B	193	13.09	1.28	11.69	19.12
Females-A	270	11.23	1.22	9.99	17.30
Females-Senior	383	12.72	1.29	11.10	18.17
High Jump					
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	470	1.48	0.04	1.45	1.66
Females-C	372	1.58	0.04	1.55	1.73
Females-B	211	1.64	0.05	1.60	1.86
Females-A	161	1.65	0.06	1.57	1.82
Females-Senior	286	1.67	0.07	1.60	1.87
Discus Throw	(D=750g; C, B, A, Senior=1kg)				
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	274	26.64	3.31	22.61	46.18
Females-C	266	30.06	3.69	25.53	48.36
Females-B	166	35.04	4.37	29.43	53.09
Females-A	182	35.19	5.08	29.15	54.01
Females-Senior	363	40.70	5.28	34.59	61.05
Hurdles Short	(D=60m & 76.2cm height; C=80m & 76.2cm height; B=100m & 76.2cm height; A, Senior=100m & 84cm height)				
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	275	10.22	0.30	9.35	10.79
Females-C	278	12.51	0.31	11.41	13.11
Females-B	240	15.19	0.49	13.79	16.24
Females-A	224	15.61	0.75	13.82	16.95
Females-Senior	333	14.92	0.84	13.05	16.55
Sprint	(D=60m; C=80m; B, A, Senior=100m)				
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	292	8.37	0.14	7.80	8.56
Females-C	298	10.47	0.19	9.84	10.82
Females-B	223	12.63	0.29	11.79	13.24
Females-A	237	12.62	0.32	11.56	13.24
Females-Senior	338	12.27	0.31	11.34	12.82
Middle Distance	(D, C=600m; B, A, Senior=800m)				
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	273	105.55	2.22	95.51	109.46
Females-C	242	100.33	1.96	92.37	103.40
Females-B	190	137.77	3.65	126.66	143.60
Females-A	204	137.57	4.64	121.76	145.33
Females-Senior	336	131.43	4.21	118.85	138.65
Hurdles Long	(C=300m & 76.2cm height; B, A, Senior=400m & 76.2cm height)				
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-C	262	49.22	1.78	44.56	53.16
Females-B	189	68.97	3.78	59.44	79.94
Females-A	181	69.76	4.32	56.26	79.21
Females-Senior	300	65.06	3.45	55.64	72.17
Long Distance	(D, C= 1000m; B, A, Senior= 1500m)				
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-D	268	193.74	8.78	175.18	315.17
Females-C	401	245.55	61.54	171.90	330.95
Females-B	200	278.78	37.08	170.62	320.47
Females-A	211	280.15	35.82	166.98	318.65
Females-Senior	424	257.70	39.12	162.34	294.36
400m					
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-B	199	59.19	1.59	54.96	61.77
Females-A	201	58.91	1.77	53.67	61.73
Females-Senior	325	57.18	1.68	52.64	59.58

Table A3b continued

3000m					
Age category	*n*	*mean*	*SD*	*min*	*max*
Females-B	125	654.34	38.59	558.24	719.65
Females-A	147	646.06	40.54	555.88	719.22
Females-Senior	421	606.13	25.29	537.84	651.34

*From 2009 onwards the weight for Females-C changed to 500 g. Although this makes it easier to perform better, separate summary statistics per season did not reveal any differences and, therefore, this change is not taken into account any further.

Appendix A4

Table A4a: estimation results for male athletes, complete table

Long Jump	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
	Distance	Distance	Distance	Distance	Distance	Distance
Q2	-0.062	-0.172**	-0.061	-0.083	-0.048	-0.091**
	(-0.691)	(-3.202)	(-1.150)	(-1.062)	(-0.747)	(-3.201)
Q3	-0.371**	-0.260**	-0.104*	-0.160**	-0.144*	-0.162**
	(-6.445)	(-5.417)	(-1.795)	(-2.110)	(-1.800)	(-5.243)
Q4	-0.460**	-0.433**	-0.301**	-0.270**	-0.216**	-0.110**
	(-10.006)	(-9.362)	(-4.337)	(-3.133)	(-3.121)	(-4.314)
clubranking	-0.001	-0.015**	-0.002	-0.016	-0.031**	-0.049**
	(-0.179)	(-2.100)	(-0.289)	(-1.501)	(-3.282)	(-10.427)
Constant	5.376**	6.438**	6.679**	6.889**	6.999**	7.411**
	(52.256)	(68.151)	(65.259)	(49.357)	(61.156)	(132.890)
Observations	106	100	99	89	102	487
Adj. R^2	0.424	0.416	0.188	0.076	0.196	0.348
Season FE	YES	YES	YES	YES	YES	YES
F-test	14.156	12.024	4.320	1.858	5.436	14.639
Prob > F	0.000	0.000	0.000	0.046	0.000	0.000

High Jump	**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**
	Distance	Distance	Distance	Distance	Distance	Distance	Distance
Q2	-0.006	-0.018*	-0.021	0.011	-0.004	-0.005	-0.045**
	(-0.670)	(-1.713)	(-1.222)	(0.825)	(-0.361)	(-0.293)	(-5.535)
Q3	-0.032**	-0.050**	-0.025	-0.034**	-0.029*	-0.039*	-0.078**
	(-3.287)	(-4.795)	(-1.497)	(-2.322)	(-1.691)	(-1.864)	(-8.506)
Q4	-0.051**	-0.050**	-0.041**	-0.018	-0.022	-0.028	-0.061**
	(-6.158)	(-4.274)	(-2.491)	(-1.572)	(-1.602)	(-1.554)	(-6.166)
clubranking	-0.000	-0.004**	-0.002	-0.005**	-0.004	-0.005*	-0.012**
	(-0.164)	(-2.571)	(-0.922)	(-2.022)	(-1.128)	(-1.723)	(-8.988)
Constant	1.586**	1.840**	1.929**	1.939**	1.946**	2.003**	2.150**
	(83.261)	(93.496)	(36.123)	(65.886)	(54.904)	(53.787)	(138.890)
Observations	227	205	93	135	87	84	358
Adj. R^2	0.210	0.120	0.128	0.180	0.079	0.032	0.497
Season FE	YES	YES	YES	YES	YES	YES	YES
F-test	5.075	3.249	2.449	3.724	2.357	1.362	17.975
Prob > F	0.000	0.000	0.006	0.000	0.009	0.196	0.000

Pole Vault	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
	Distance	Distance	Distance	Distance	Distance
Q2	-0.196*	-0.046	-0.050	0.023	-0.150**
	(-1.811)	(-0.515)	(-0.515)	(0.202)	(-3.483)
Q3	-0.267**	-0.086	-0.082	-0.173	-0.302**
	(-2.452)	(-0.798)	(-0.705)	(-1.617)	(-7.303)
Q4	-0.680**	-0.166	-0.324**	-0.337**	-0.410**
	(-5.941)	(-1.541)	(-2.899)	(-2.666)	(-9.326)
clubranking	-0.024	-0.028**	-0.044**	-0.073**	-0.083**
	(-1.599)	(-3.022)	(-3.711)	(-5.205)	(-13.546)
Constant	3.531**	4.176**	4.431**	4.698**	5.206**
	(17.912)	(25.513)	(32.519)	(28.778)	(61.163)
Observations	81	109	107	79	488
Adj. R^2	0.363	0.117	0.240	0.446	0.527
Season FE	YES	YES	YES	YES	YES
F-test	5.737	2.093	3.698	5.826	25.850
Prob > F	0.000	0.019	0.000	0.000	0.000

Javelin	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
	Distance	Distance	Distance	Distance	Distance	Distance
Q2	0.506	0.326	-0.370	0.109	0.630	0.436
	(0.551)	(0.286)	(-0.264)	(0.090)	(0.495)	(0.831)
Q3	-3.774**	-3.559**	-1.606	-1.933	-2.391*	-3.470**
	(-4.123)	(-3.120)	(-1.029)	(-1.255)	(-1.725)	(-5.513)
Q4	-5.331**	-4.842**	-5.072**	-4.619**	-4.962**	-4.030**
	(-5.275)	(-4.073)	(-3.685)	(-4.084)	(-4.402)	(-6.864)
clubranking	-0.235	-0.150	-0.288	-0.638**	-0.906**	-1.017**
	(-1.580)	(-0.871)	(-1.325)	(-2.249)	(-3.280)	(-10.196)
Constant	43.683**	50.499**	60.114**	59.907**	60.322**	68.374**
	(22.333)	(28.845)	(18.835)	(18.489)	(20.119)	(53.858)
Observations	100	104	73	88	128	476
Adj. R^2	0.337	0.279	0.118	0.193	0.301	0.429
Season FE	YES	YES	YES	YES	YES	YES
F-test	7.027	7.153	3.276	3.455	5.028	23.066
Prob > F	0.000	0.000	0.001	0.000	0.000	0.000

Shot Put	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
	Distance	Distance	Distance	Distance	Distance	Distance
Q2	-0.120	-0.132	0.516	0.084	0.179	-0.477**
	(-0.430)	(-0.494)	(1.439)	(0.215)	(0.422)	(-3.798)
Q3	-1.300**	-0.778**	-0.191	-0.861**	-0.658	-0.342**
	(-5.566)	(-2.891)	(-0.442)	(-2.465)	(-1.404)	(-2.571)
Q4	-1.318**	-1.397**	-1.301**	-1.100**	-0.929**	-1.317**
	(-4.980)	(-4.606)	(-2.717)	(-2.796)	(-2.012)	(-10.655)
clubranking	0.022	0.001	-0.096*	-0.032	-0.142*	-0.300**
	(0.554)	(0.017)	(-1.917)	(-0.922)	(-1.665)	(-11.396)
Constant	12.530**	14.451**	16.386**	13.702**	15.391**	17.517**
	(24.312)	(27.132)	(22.061)	(33.343)	(11.382)	(61.624)
Observations	96	92	69	84	116	685
Adj. R^2	0.306	0.228	0.162	0.174	0.120	0.440
Season FE	YES	YES	YES	YES	YES	YES
F-test	5.482	3.909	2.539	5.248	3.829	24.967
Prob > F	0.000	0.000	0.007	0.000	0.000	0.000

Table A4a continued

Disc Throw	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
	Distance	Distance	Distance	Distance	Distance	Distance
Q2	-1.826*	-2.438**	-1.777	-2.028	-1.435	-2.477**
	(-1.907)	(-2.571)	(-1.291)	(-1.369)	(-0.906)	(-5.741)
Q3	-4.797**	-4.537**	-3.968**	-4.317**	-4.226**	-1.146**
	(-6.983)	(-5.014)	(-2.637)	(-2.318)	(-2.379)	(-2.328)
Q4	-5.317**	-5.748**	-5.247**	-4.933**	-3.243*	-2.040**
	(-6.575)	(-5.905)	(-3.247)	(-3.037)	(-1.762)	(-4.480)
clubranking	0.133	0.050	0.073	-0.204	-1.094**	-1.025**
	(0.997)	(0.510)	(0.381)	(-1.067)	(-2.881)	(-10.804)
Constant	32.596**	48.227**	47.670**	43.440**	53.469**	54.736**
	(17.746)	(30.696)	(16.766)	(18.746)	(10.105)	(53.042)
Observations	100	92	72	77	84	789
Adj. R^2	0.336	0.345	0.131	0.080	0.247	0.364
Season FE	YES	YES	YES	YES	YES	YES
F-test	8.610	6.453	2.636	4.249	4.003	14.531
Prob > F	0.000	0.000	0.005	0.000	0.000	0.000
Hurdles Short	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
	Time	Time	Time	Time	Time	Time
Q2	0.001	0.177*	0.165	0.244	0.208	0.019
	(0.008)	(1.756)	(1.347)	(1.477)	(1.393)	(0.385)
Q3	0.487**	0.500**	0.338**	0.376**	0.577**	0.014
	(6.125)	(5.228)	(2.613)	(2.439)	(2.996)	(0.254)
Q4	0.747**	0.913**	0.950**	0.745**	0.801**	0.470**
	(6.797)	(10.658)	(6.453)	(5.467)	(5.457)	(7.162)
clubranking	-0.001	0.002	0.029*	0.073**	0.070**	0.120**
	(-0.090)	(0.247)	(1.783)	(2.955)	(2.590)	(14.348)
Constant	12.481**	13.833**	14.570**	14.667**	14.191**	14.204**
	(67.460)	(93.313)	(60.395)	(52.071)	(40.065)	(135.070)
Observations	86	85	85	116	112	508
Adj. R^2	0.560	0.586	0.394	0.181	0.154	0.504
Season FE	YES	YES	YES	YES	YES	YES
F-test	15.289	13.576	6.637	4.814	3.876	30.174
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
Sprint	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
	Time	Time	Time	Time	Time	Time
Q2	0.099*	0.198**	0.234**	0.143**	0.100	0.015
	(1.699)	(3.552)	(3.463)	(2.581)	(1.655)	(0.650)
Q3	0.399**	0.290**	0.174**	0.171**	0.137**	-0.006
	(6.614)	(4.500)	(3.115)	(2.868)	(2.212)	(-0.215)
Q4	0.650**	0.402**	0.368**	0.276**	0.337**	0.157**
	(12.028)	(6.614)	(6.647)	(4.414)	(5.723)	(6.747)
clubranking	-0.003	0.004	0.005	0.023**	0.025**	0.032**
	(-0.282)	(0.387)	(0.458)	(2.984)	(3.729)	(12.171)
Constant	10.089**	11.356**	11.123**	10.841**	10.825**	10.620**
	(74.216)	(101.639)	(87.427)	(113.794)	(113.594)	(276.424)
Observations	88	84	88	110	119	686
Adj. R^2	0.612	0.443	0.305	0.264	0.393	0.318
Season FE	YES	YES	YES	YES	YES	YES
F-test	15.252	7.414	6.690	4.325	7.845	21.034
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
Hurdles Long		**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
		Time	Time	Time	Time	Time
Q2		0.726**	0.300	1.464**	1.587**	0.315*
		(2.426)	(0.420)	(2.196)	(2.221)	(1.835)
Q3		2.542**	2.918**	3.557**	3.128**	0.925**
		(7.063)	(3.346)	(4.281)	(3.946)	(5.003)
Q4		3.548**	2.729**	2.213**	3.857**	1.902**
		(9.350)	(3.338)	(2.932)	(3.930)	(7.356)
clubranking		0.056	0.067	0.405**	0.391**	0.409**
		(0.852)	(0.684)	(2.282)	(2.013)	(13.373)
Constant		40.746**	54.675**	52.860**	51.311**	51.129**
		(50.517)	(35.173)	(25.215)	(31.008)	(131.151)
Observations		105	84	92	84	438
Adj. R^2		0.506	0.168	0.210	0.284	0.460
Season FE		YES	YES	YES	YES	YES
F-test		10.841	2.414	2.780	4.714	23.752
Prob > F		0.000	0.008	0.002	0.000	0.000
Middel Distance	**D-2**	**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
	Time	Time	Time	Time	Time	Time
Q2	-0.167	0.070	1.131**	1.149**	0.587	0.489**
	(-0.129)	(0.061)	(2.067)	(1.995)	(1.080)	(2.113)
Q3	3.463**	4.077**	1.191*	2.761**	1.596**	1.306**
	(2.502)	(4.093)	(1.840)	(5.142)	(2.926)	(5.271)
Q4	5.941**	3.182**	1.826**	2.557**	1.673**	0.173
	(4.117)	(2.315)	(2.897)	(4.441)	(2.664)	(0.794)
clubranking	0.197	-0.317	0.026	0.082	0.297**	0.452**
	(0.783)	(-1.344)	(0.341)	(0.904)	(2.962)	(12.295)
Constant	93.764**	125.940**	116.985**	112.950**	111.042**	108.589**
	(34.446)	(34.739)	(119.996)	(85.881)	(84.100)	(193.613)
Observations	40	132	112	137	148	701
Adj. R^2	0.379	0.235	0.012	0.241	0.212	0.339
Season FE	YES	YES	YES	YES	YES	YES
F-test	7.541	3.136	1.174	4.372	2.844	16.060
Prob > F	0.000	0.000	0.307	0.000	0.001	0.000

Table A4a continued

Long Distance	**D-2**	**C-2**	**B-2**	**B-1**	**A-1**	**A-2**	**Senior**
	Time	Time	Time	Time	Time	Time	Time
Q2	2.093**	-0.918	0.971	-0.099	-2.508*	0.853	-1.221**
	(2.305)	(-0.549)	(0.624)	(-0.070)	(-1.758)	(0.571)	(-2.327)
Q3	6.595**	4.462**	1.184	0.163	0.045	1.130	1.115**
	(6.177)	(2.610)	(0.802)	(0.102)	(0.035)	(0.785)	(1.999)
Q4	8.476**	5.646**	3.994**	4.086**	1.190	2.457	-1.562**
	(8.303)	(3.540)	(2.028)	(2.687)	(0.796)	(1.523)	(-3.095)
clubranking	-0.173	0.001	0.267	0.524**	0.502**	0.934**	1.012**
	(-1.012)	(0.005)	(1.209)	(2.930)	(2.266)	(3.766)	(12.996)
Constant	174.796**	262.785**	247.517**	243.674**	240.546**	231.181**	225.902**
	(78.505)	(92.561)	(84.426)	(103.885)	(78.129)	(66.180)	(205.037)
Observations	108	148	65	116	136	168	676
Adj. R^2	0.518	0.116	0.121	0.090	0.106	0.129	0.346
Season FE	YES	YES	YES	YES	YES	YES	YES
F-test	12.353	2.761	5.818	2.245	2.148	2.145	18.223
Prob > F	0.000	0.001	0.000	0.011	0.014	0.012	0.000

*Note: Robust t-statistics are indicated between brackets. **p<0.05, *p<0.1. Each top row of the sub tables consists of the discipline followed by the age category, in which the number is a year indicator (i.e. 1 means first year athletes, 2 means second year athletes).*

Table A4b: estimation results for female athletes, complete table

Long Jump	D-2	C-2	B-1	B-2	A-1	Senior
	Distance	Distance	Distance	Distance	Distance	Distance
Q2	-0.111**	0.038	-0.005	0.088	0.099	0.209**
	(-2.569)	(0.786)	(-0.082)	(1.337)	(1.616)	(6.545)
Q3	-0.184**	-0.063	-0.084	0.039	0.043	0.116**
	(-4.235)	(-1.354)	(-1.423)	(0.676)	(0.861)	(3.309)
Q4	-0.236**	-0.080*	-0.041	0.035	-0.026	0.155**
	(-3.819)	(-1.743)	(-0.589)	(0.533)	(-0.411)	(3.764)
clubranking	0.003	-0.006	-0.009	-0.018*	-0.035**	-0.042**
	(0.552)	(-1.138)	(-1.103)	(-1.949)	(-3.987)	(-8.388)
Constant	4.990**	5.265**	5.456**	5.604**	5.816**	5.812**
	(71.255)	(75.217)	(51.113)	(37.784)	(44.767)	(82.426)
Observations	89	113	80	76	84	282
Adj. R^2	0.172	0.078	-0.030	0.059	0.314	0.395
Season FE	YES	YES	YES	YES	YES	YES
F-test	3.054	1.790	0.941	0.951	3.406	12.942
Prob > F	0.001	0.051	0.521	0.512	0.000	0.000

High Jump	D-2	C-1	C-2	B-1	B-2	A-2	Senior
	Distance	Distance	Distance	Distance	Distance	Distance	Distance
Q2	0.002	-0.009	-0.015**	0.002	0.030**	0.014	0.067**
	(0.241)	(-0.714)	(-1.979)	(0.142)	(2.274)	(0.804)	(7.152)
Q3	-0.045**	-0.041**	-0.010	-0.011	0.003	0.027	0.024**
	(-6.207)	(-4.110)	(-1.172)	(-0.958)	(0.231)	(1.637)	(2.773)
Q4	-0.057**	-0.039**	-0.011	-0.014	0.022	-0.023	0.032**
	(-6.971)	(-3.188)	(-1.203)	(-0.956)	(1.228)	(-1.419)	(3.077)
clubranking	-0.000	0.001	-0.003**	-0.011*	-0.005	-0.014**	-0.011**
	(-0.215)	(0.563)	(-2.175)	(-1.726)	(-1.473)	(-5.880)	(-8.813)
Constant	1.529**	1.592**	1.641**	1.743**	1.704**	1.788**	1.749**
	(92.981)	(82.100)	(86.202)	(24.724)	(39.910)	(63.034)	(78.787)
Observations	221	82	238	86	82	76	231
Adj. R^2	0.263	0.286	0.084	0.196	0.166	0.489	0.602
Season FE	YES	YES	YES	YES	YES	YES	YES
F-test	8.285	4.308	4.175	10.175	4.721	8.105	35.960
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Javelin	D-2	C-2	B-2	A-1	A-2	Senior
	Distance	Distance	Distance	Distance	Distance	Distance
Q2	-1.190	-0.271	0.700	0.556	0.921	1.003
	(-1.372)	(-0.320)	(0.555)	(0.499)	(0.805)	(1.481)
Q3	-4.127**	-3.772**	-1.384	-2.952**	-0.724	-0.380
	(-7.055)	(-3.736)	(-1.127)	(-2.420)	(-0.627)	(-0.536)
Q4	-4.262**	-4.020**	-1.630	-2.601**	-3.102**	-2.427**
	(-7.520)	(-4.895)	(-1.228)	(-2.606)	(-2.467)	(-3.169)
clubranking	-0.117	-0.192	-0.494**	-1.046**	-1.133**	-0.952**
	(-0.998)	(-1.620)	(-2.638)	(-5.895)	(-4.325)	(-9.569)
Constant	34.210**	38.298**	44.176**	50.344**	49.754**	51.746**
	(22.090)	(19.153)	(13.953)	(21.148)	(11.351)	(44.293)
Observations	136	104	76	76	80	184
Adj. R^2	0.341	0.267	0.259	0.482	0.466	0.596
Season FE	YES	YES	YES	YES	YES	YES
F-test	9.138	4.256	3.397	6.558	5.509	23.558
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000

Shot Put	D-2	C-2	B-2	A-1	A-2	Senior
	Distance	Distance	Distance	Distance	Distance	Distance
Q2	0.536	0.800*	0.742*	0.496	0.462	0.509**
	(1.198)	(1.946)	(1.751)	(1.618)	(1.631)	(2.819)
Q3	-0.999**	-0.580*	-1.016**	-0.552**	-0.481*	-0.354*
	(-4.377)	(-1.975)	(-2.922)	(-2.239)	(-1.872)	(-1.884)
Q4	-1.510**	-0.665*	-0.876**	-0.252	-0.141	0.228
	(-4.293)	(-1.928)	(-2.528)	(-0.970)	(-0.497)	(1.291)
clubranking	-0.031	-0.059	-0.158**	-0.089*	-0.184**	-0.202**
	(-0.654)	(-1.311)	(-2.902)	(-1.824)	(-3.720)	(-8.094)
Constant	13.339**	12.589**	15.556**	11.873**	13.442**	14.818**
	(22.238)	(25.421)	(19.285)	(18.288)	(21.121)	(45.254)
Observations	68	94	76	113	96	240
Adj. R^2	0.446	0.208	0.363	0.138	0.310	0.370
Season FE	YES	YES	YES	YES	YES	YES
F-test	6.477	2.931	3.639	2.010	2.126	6.930
Prob > F	0.000	0.001	0.000	0.024	0.018	0.000

Disc Throw	D-2	C-2	B-2	A-1	A-2	Senior
	Distance	Distance	Distance	Distance	Distance	Distance
Q2	3.337**	1.662	2.767**	2.320	2.959*	2.957**
	(3.055)	(1.459)	(2.269)	(1.526)	(1.876)	(4.129)
Q3	-1.929**	-2.539**	-4.255**	-4.085**	-3.337**	-0.397
	(-2.792)	(-2.771)	(-3.047)	(-3.542)	(-2.208)	(-0.503)
Q4	-2.321**	-4.191**	-3.548**	-3.215**	0.019	2.729**
	(-2.929)	(-3.855)	(-2.514)	(-2.675)	(0.013)	(3.392)
clubranking	-0.050	-0.259	-0.403**	-0.834**	-0.740**	-1.056**
	(-0.481)	(-1.101)	(-2.282)	(-3.801)	(-3.337)	(-11.463)
Constant	29.544**	35.441**	41.135**	44.940**	44.420**	50.908**
	(24.323)	(12.887)	(13.785)	(18.083)	(11.939)	(35.696)
Observations	104	84	68	64	56	184
Adj. R^2	0.374	0.296	0.438	0.446	0.479	0.625
Season FE	YES	YES	YES	YES	YES	YES
F-test	6.516	4.732	5.082	6.756	15.128	19.363
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000

Table A4b continued

Hurdles Short		**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**
		Time	Time	Time	Time	Time	Time	Time
Q2		0.030	-0.072	-0.571**	-0.401**	-0.760**	-0.628**	-0.395**
		(0.475)	(-1.086)	(-4.894)	(-3.131)	(-4.361)	(-2.737)	(-3.937)
Q3		0.276**	0.137**	-0.145	0.003	0.060	-0.169	0.384**
		(3.840)	(2.006)	(-1.422)	(0.028)	(0.332)	(-0.781)	(3.041)
Q4		0.459**	0.186**	-0.036	0.001	0.058	0.005	0.170
		(5.611)	(2.335)	(-0.263)	(0.009)	(0.314)	(0.024)	(1.583)
clubranking		-0.000	0.008	0.004	0.029	0.031	0.070*	0.101**
		(-0.061)	(0.637)	(0.226)	(1.479)	(1.190)	(1.909)	(7.297)
Constant		9.525**	12.311**	15.217**	14.640**	15.382**	14.962**	13.862**
		(60.546)	(67.536)	(58.154)	(41.270)	(38.600)	(36.702)	(80.629)
Observations		84	129	85	94	92	80	197
Adj. R^2		0.343	0.150	0.207	0.141	0.296	0.151	0.513
Season FE		YES	YES	YES	YES	YES	YES	YES
F-test		4.334	6.393	3.106	2.454	4.937	2.778	30.470
Prob > F		0.000	0.000	0.001	0.006	0.000	0.003	0.000
Sprint		**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**
		Time	Time	Time	Time	Time	Time	Time
Q2		-0.024	-0.033	-0.041	-0.004	-0.090	-0.134*	-0.179**
		(-0.742)	(-0.798)	(-0.605)	(-0.053)	(-1.275)	(-1.951)	(-5.068)
Q3		0.062**	0.077*	0.061	0.168**	0.101	0.074	-0.007
		(1.997)	(1.832)	(0.982)	(2.560)	(1.400)	(1.209)	(-0.157)
Q4		0.093**	0.076*	0.039	0.100	0.010	0.158**	-0.243**
		(2.099)	(1.674)	(0.641)	(1.594)	(0.130)	(2.146)	(-5.522)
clubranking		-0.004	0.008	0.015	0.041**	0.037**	0.036**	0.039**
		(-0.945)	(1.243)	(1.336)	(3.635)	(3.337)	(3.915)	(7.970)
Constant		8.246**	10.470**	12.289**	12.029**	12.430**	12.485**	11.968**
		(155.786)	(142.899)	(79.477)	(80.109)	(76.928)	(81.622)	(158.399)
Observations		124	132	93	104	112	108	241
Adj. R^2		0.083	0.182	0.278	0.331	0.333	0.418	0.482
Season FE		YES	YES	YES	YES	YES	YES	YES
F-test		2.019	6.305	4.618	3.363	6.368	6.416	18.228
Prob > F		0.022	0.000	0.000	0.000	0.000	0.000	0.000
Hurdles Long				**C-2**	**B-2**	**A-1**	**A-2**	**Senior**
				Time	Time	Time	Time	Time
Q2				-0.307	0.746	1.370	-0.809	-0.401
				(-0.888)	(0.864)	(1.240)	(-0.807)	(-1.295)
Q3				0.954**	2.467**	1.730*	3.957**	2.304**
				(2.168)	(2.508)	(1.801)	(2.496)	(5.559)
Q4				0.300	-0.149	1.978*	2.562**	1.126**
				(0.701)	(-0.170)	(1.978)	(2.481)	(2.937)
clubranking				0.051	0.792**	0.555**	0.573**	0.543**
				(0.856)	(4.973)	(3.546)	(2.244)	(10.149)
Constant				47.641**	59.379**	62.905**	62.407**	58.450**
				(55.634)	(32.228)	(27.304)	(14.128)	(70.926)
Observations				112	68	100	56	192
Adj. R^2				0.050	0.411	0.118	0.299	0.615
Season FE				YES	YES	YES	YES	YES
F-test				1.426	3.916	2.248	4.560	23.133
Prob > F				0.156	0.000	0.012	0.000	0.000
Middle Distance		**D-2**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**
		Time	Time	Time	Time	Time	Time	Time
Q2		1.355**	-0.233	-1.025	0.815	-0.852	1.354	0.048
		(2.808)	(-0.472)	(-1.203)	(0.705)	(-0.599)	(0.887)	(0.124)
Q3		2.144**	0.499	-2.824**	-0.563	-0.772	2.717*	0.985**
		(3.762)	(0.902)	(-2.613)	(-0.553)	(-0.608)	(1.778)	(2.207)
Q4		3.322**	0.688	2.057	3.052**	1.449	3.237**	3.255**
		(5.682)	(1.220)	(1.517)	(2.856)	(1.013)	(2.317)	(6.281)
clubranking		0.527**	-0.017	0.211*	0.372	0.219	0.532**	0.702**
		(5.911)	(-0.258)	(1.692)	(1.410)	(1.187)	(2.336)	(10.898)
Constant		96.248**	99.314**	133.811**	133.606**	135.835**	128.345**	123.756**
		(76.959)	(122.869)	(66.850)	(40.390)	(60.906)	(32.291)	(165.375)
Observations		88	120	68	84	104	84	244
Adj. R^2		0.406	0.073	0.227	0.154	0.114	0.175	0.543
Season FE		YES	YES	YES	YES	YES	YES	YES
F-test		6.421	2.008	4.894	3.393	3.119	2.143	19.182
Prob > F		0.000	0.024	0.000	0.000	0.001	0.019	0.000
Long Distance	**D-2**	**C-1**	**C-2**	**B-1**	**B-2**	**A-1**	**A-2**	**Senior**
	Time	Time	Time	Time	Time	Time	Time	Time
Q2	1.019	22.027	2.140	-17.240	2.870	16.554**	4.858	-5.842
	(0.871)	(1.561)	(0.221)	(-1.244)	(0.298)	(2.122)	(0.461)	(-0.919)
Q3	1.945*	22.210	-8.967	-31.367**	1.780	4.257	2.455	-7.737
	(1.695)	(1.541)	(-1.318)	(-2.776)	(0.166)	(0.458)	(0.209)	(-1.144)
Q4	5.228**	41.397**	45.731**	16.913*	6.950	3.904	3.514	9.798
	(4.136)	(2.879)	(3.867)	(1.981)	(0.713)	(0.351)	(0.329)	(1.632)
clubranking	0.343	-1.319	-1.844	1.684	6.205**	6.767**	5.612**	3.957**
	(1.574)	(-0.567)	(-1.115)	(1.208)	(3.387)	(3.793)	(3.010)	(6.089)
Constant	184.089**	222.786**	209.358**	248.141**	223.912**	197.147**	237.037**	216.786**
	(53.833)	(6.902)	(9.343)	(9.286)	(9.901)	(7.494)	(11.749)	(21.427)
Observations	104	144	152	72	84	88	72	300
Adj. R^2	0.258	-0.027	0.136	0.213	0.326	0.327	0.174	0.193
Season FE	YES	YES	YES	YES	YES	YES	YES	YES
F-test	4.120	0.833	2.017	2.335	2.703	3.567	1.687	8.608
Prob > F	0.000	0.633	0.021	0.013	0.003	0.000	0.084	0.000

*Note: Robust t-statistics are indicated between brackets. **p<0.05, *p<0.1. Each top row of the sub tables consists of the discipline followed by the age category, in which the number is a year indicator (i.e. 1 means first year athletes, 2 means second year athletes).*

Appendix A5

The table below is an example of the performance based selection system as used by the KNAU (In Dutch).[58]

TALENTENMATRIX SPRINT seizoen 2011-2012

	vrouwen	2ejr D 1999 13jr	1e C 1998 14 jaar	2e C 1997 15 jaar	1e B 1996 16 jaar	2e B 1995 17 jaar	1e A 1994 18 jaar	2e A 1993 19 jaar	1e <23 1992 20 jaar	2e <23 1991 21 jaar	3e <23 1990 22 jaar
100	nationale selectie		12,60	12,50	12,30	12,20	12,10	11,95	11,85	11,75	11,60
	regionale selectie		12,90	12,70	12,50	12,30					
60 / 80m	nationale selectie		10,35	10,15							
	regionale selectie	8,45	10,80	10,55							
200	nationale selectie			25,50	25,20	24,90	24,60	24,30	24,10	23,95	23,85
	regionale selectie			25,85	25,60	25,40					
400	nationale selectie				57,00	56,00	55,30	54,70	54,20	53,80	53,50
	regionale selectie				58	57,2					

	mannen	2e jr D 1999 13jr	1e C 1998 14 jaar	2e C 1997 15 jaar	1e B 1996 16 jaar	2e B 1995 17 jaar	1e A 1994 18 jaar	2e A 1993 19 jaar	1e <23 1992 20 jaar	2e <23 1991 21 jaar	3e <23 1990 22 jaar
100	nationale selectie		11,35	11,25	11,15	11,05	10,95	10,80	10,70	10,60	10,50
	regionale selectie		11,75	11,60	11,45	11,30					
80m	nationale selectie										
	regionale selectie	10,50									
200	nationale selectie			23,10	22,70	22,30	22,00	21,80	21,55	21,35	21,15
	regionale selectie			23,70	23,30	22,90					
400	nationale selectie				50,00	49,00	48,50	47,90	47,50	47,10	46,70
	regionale selectie				50,9	49,9					

kijkwijzer: rij in oranje is de richtlijn om opgenomen te worden in de nationale selectie
rij in blauw is de richtlijn op opgenomen te worden in de regionale selectie

selectie wordt gebaseerd op prestatie van het afgelopen seizoen

regio: richt zich op D2, C en B junioren
nationale selectie: richt zich voornamelijk op B en A junioren

[58]Source:http://www.atletiekunie.nl/upload/File/Dutch%20Athletics%20Team/talentmatrix%20sprint%202012.pdf.