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Early diversification in team sports, pathway to success?

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Abstract

The aim of this study was to further investigate the relationship between number of sports, amount of early diversification vs. early specialization during childhood and performance level in adolescence, in team sports. To investigate this, participants from the Topsport Talentschool in Groningen have been asked to elaborate on their sport participation patterns during childhood and their current sport participation through an online questionnaire. For the first hypothesis a positive relation between number of sports, amount of early diversification and current level were expected. The results showed only a significant positive relation for current hours of weekly practice and current performance level. Further no significant relations between the variables have been found. For the second hypothesis, two groups were made for each variable, dividing the participants in less vs. many hours of practice. A difference between those groups was expected in performance level. However, we found no significant differences between those groups for each variable, in current performance level. Thus, these findings were not in line with the formulated hypothesis. For future research it is important to create a broader perspective of the sport participation patterns during childhood. By looking further into the participation patterns, maybe a more definite answer can be found to the question which of the pathways is better for reaching excellence. This can help athletes and coaches in the future to follow more efficient roads to success.

Keywords: Early Diversification, Early Specialization, Sports Psychology, Sport Expertise

Early diversification in team sports, pathway to success?

As a child, there are many different sports one can choose from. It could be that the child tries out some different sports before deciding upon the favorite one. Others just pick the favorite one right away, and stick with that during their youth growing up. But what path can be beneficial for developing talents and later expertise? What the best predictor is of later expertise is a question that has interested researchers in the past decades. These two possible roads of choosing sports can be seen as two different pathways which can lead to expertise in sports. In the talent development literature, they are called ‘early specialization’ and ‘early diversification’. Early specialization means ‘investment in one activity and deliberate practice from a young age’, while early diversification means ‘early participation in a wide variety of sports with a high level of deliberate play and low levels of deliberate practice’ (Coutinho et al., 2016).

When studying the development of early talent, it can be important to keep those pathways in mind. After studying these pathways researchers have shown that both pathways have their pros and cons with regards to them leading to expertise. Ericsson et al. (1993) stated that early specialization with deliberate practice is essential to the development of expertise in any domain. But early specialization has also been associated with negative consequences such as injuries, decreased enjoyment and dropout (Baker, 2003; Dalton, 1992; Butcher et al., 2002). While play-like involvement in a number of sports, as in early diversification, is beneficial for developing the intrinsic motivation required during later stages of development when training becomes more structured and effortful (Côté, 1999; Côté & Hay, 2002; Côté et al., 2003). Moreover, early diversification has been shown the more common pathway for sports that have their peak performance in adulthood, such as team sports like basketball and volleyball (Coutinho et al. 2015; Baker et al. 2003). However,

Baker & Côté (2006) suggest that early diversification alone is unable to nurture elite athletes in the long-term, it matters in which way diversification appears.

Although there is some evidence regarding both pathways for development of expertise, it is still uncertain which pathway is the better way to reach excellence in sports. Baker et al. (2009) stated some limitations of the previous studies and directions for future work. One of them being that there is more research required to determine whether the early diversification approach applies to all different sport types and for all skill levels. Baker et al., (2003) stated that in team sports, contradictory to individual sports, the development of expertise requires mastery in a wide range of different skills. Just as in individual sports physical fitness is important, but also practice in specific elements such as team strategies are necessary to improve the overall performance. Because of these differences between individual and team sports, we chose to only look at team sports for the current study. Hence, this research is aiming to provide more information on the topic of amount of early specialization vs. early diversification for team sports and different skill levels.

Early specialization with deliberate practice

First, we will have a look into the current knowledge about these two pathways. As mentioned before, early specialization entails the start in one specific sport at an early age. So, when going with the early specialization pathway, children will play one sport and invest in a lot of practice hours from a young age. The investment is mostly in the form of deliberate practice. Ericsson et al. (1993) firstly stated the importance of intensive practice for reaching excellence. They came up with the '10-year rule' which means that before someone could reach the expert level there must have been a 10-year (10,000 hours) commitment to high levels of training. Thereby, they mentioned that the individuals also need to be engaged in deliberate practice and not just any basic training sessions. Deliberate practice is task specific practice that is instructed and monitored by a coach to improve one's performance. It involves

frequent repetition of a task, is highly effortful, and not inherently enjoyable (Ericsson et al., 1993).

During deliberate practice, the athletes are involved in training sessions where required skills are developed under continuously evolving conditions. In these conditions training stress and recovery are optimally balanced, in that way maximal training transformations can occur and training plateaus are minimized (Baker, 2003). It has been shown that after practice, individuals first show a big increase in their rate of learning, but over time this rate of learning decreases as practice continues. This is called the power law of practice (Newell & Rosenbloom, 1981). Basically, what it means is that after time has passed it becomes more difficult to improve as quickly as someone did before. This indirectly led Ericsson (1993) to state that the earlier someone begins with deliberate practice and very focused training, the bigger the chance of achieving excellence in adulthood.

Concluding, for early specialization the focus lies on starting early in one particular sport. To reach the expert level within that sport, it is stated that it is important to accumulate many hours deliberate practice into the sport from a young age. But there is also another pathway for reaching excellence in sports. And that is the pathway called 'early diversification'.

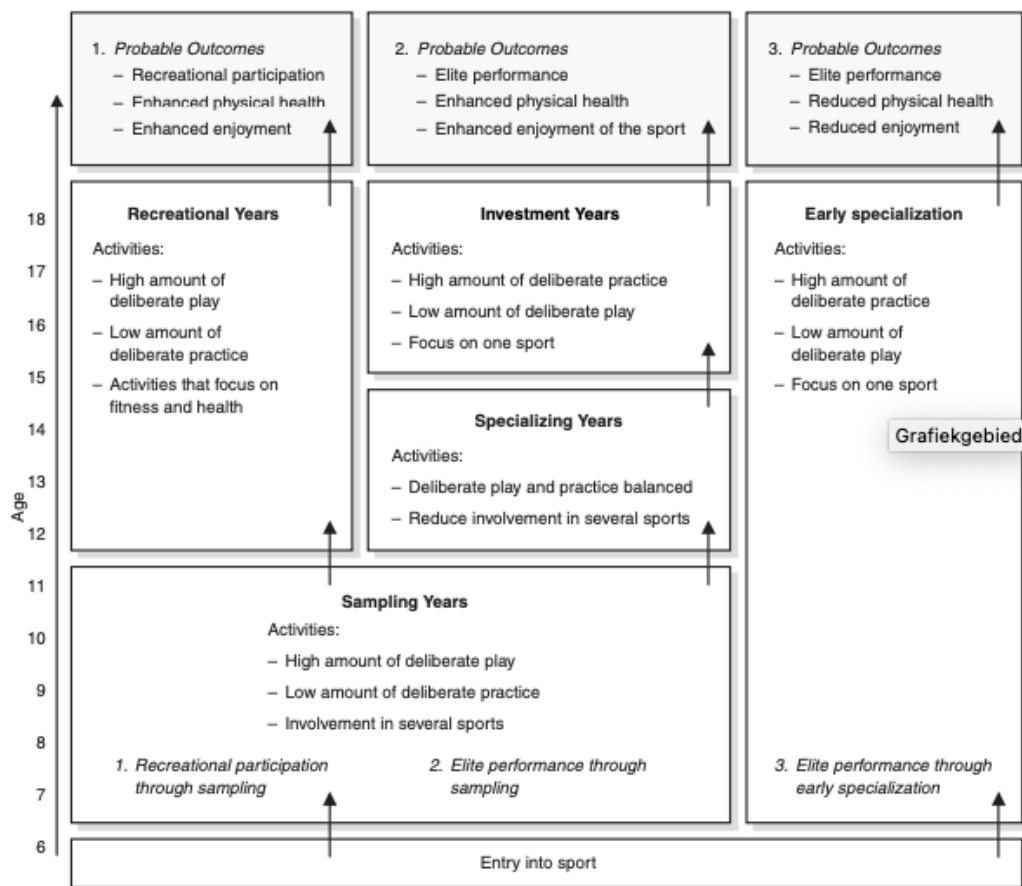
Early diversification with deliberate play

The other pathway children/athletes can follow is that of early diversification. Early diversification means that children will participate in a wide variety of sports from a young age before specializing in one sport at a later age. Côté (1999) first introduced the Developmental Model of Sport Participation (DMSP). Back then, he identified three stages to development of sport behavior from childhood to adolescence. These three stages are the sampling years (ages 6-12), the specializing years (ages 13-15) and the investment years (age 16+). During the sampling years, mainly the parents are responsible for getting their children

involved in sports, the children are given the chance to sample a wide variety of different sports. In the specializing years, the child will narrow its focus to one or two specific sports. Lastly, the investment years, here the child will become committed to one sport, trying to achieve an elite level. During the sampling and specializing years, fun and excitement is a main purpose. This can be achieved through high levels of deliberate play. Later Côté and colleagues modified the DMSP to illustrate the possible sport trajectories more clearly. This model can be found in figure 1. According to this model there are three possible entries into sport: 1) recreational participation through sampling 2) elite performance through sampling and 3) elite performance through early specialization. After that the same stages of development will occur as in the first version of the model (Côté, 1999; Côté et al., 2007; Côté & Fraser-Thomas, 2007).

Figure 1

Developmental Model of Sport Participation (Côté, 1999; Côté et al., 2007; Côté & Fraser-Thomas, 2007)



Côté and Hay (2002) introduced the concept of deliberate play. These deliberate play sessions are designed to maximize inherent enjoyment. The rules within a deliberate play environment are adapted from standard sport rules and are monitored by the children themselves or by adults. Looking at the DMSP, the sampling years are characterized by a low frequency of deliberate practice and a high frequency of deliberate play, in the specializing years this division is somewhat equal, and the investment years are characterized by high frequency of deliberate practice and a low frequency of deliberate play (Côté, 1999; Côté and Hay, 2002).

The effects of early diversification on the development of skills are likely linked to transfer of learning and cross-training (Baker, 2003). In a study of Thorndike (1914) he already suggested that identical items between tasks are transferable. These effects are the strongest during early stages of involvement (Schmidt & Wrisberg, 2000), corresponding with the sampling years in the DMSP (Côté, 1999; Côté et al., 2007; Côté & Fraser-Thomas, 2007). Schmidt and Wrisberg (2000) divided transferable items into different categories. These categories are ‘movement elements’ (refers to anatomical actions required to perform a task), ‘perceptual elements’ (refers to the interaction with the environment and decisions that the athletes make based upon that interaction) and ‘conceptual elements’ (refers to the strategies and rules of a certain game). Baker et al., (2003) also stated that a transfer of learning occurs from one sport to another, including both cognitive and physical abilities. It is important that the different sports share similar elements for cross training effects to happen. For example, Millet et al. (2002) found that cross training effects did occur between cycling and running, so sports with similarities in movement elements, but not for swimming. Looking at examples of team sports, Abernethy et al. (2005) investigated the transfer of pattern reading skills between different team ball sports. They investigated this within netball, basketball and hockey players. The results showed that ‘the sport-specific experts consistently

recalled the patterns from their domain with greater accuracy than did the non-experts’.

Besides that, they also observed that experts from one of the team sports, for example basketball, were able to perform almost or just as good in another’s sport recall task, as the experts of that other sport, for example netball. Which suggests that particular skills can be transferable between some sports.

So, for early diversification the focus lies on sampling different sports during youth, with high levels of deliberate play. Transfer and cross training effects can occur in different situations. But comparing this with the early specialization pathway, what is the better one for reaching excellence in sports?

Comparing early specialization with early diversification.

Important to mention before looking at which pathway is the better one for reaching excellence, is that there will always be individual differences and preferences. The developmental pathway is not the only factor that contributes to reaching excellence in sport. According to Portenga (2019) ‘An essential component of talent development in sport is the young athletes’ ability to undertake the talent development journey. To progress from one level to another, developing athletes need to outperform their peers during practice and competition. Thus, developing athletes manage the dual goals of improving their sport-specific characteristics enough to compete at a high standard as juniors while at the same time actively training to increase likelihood of reaching senior elite levels.’ Besides that, not only the amount of practice can influence the possibility of reaching excellence. Rees et al., (2016) provided current talent development knowledge and evidence across three key topics: a) the performer; b) the environment; and c) practice and training. Hence, also the performer and environment can play a role in reaching excellence. But for now, we will only focus on practice and training in the form of the developmental pathways.

For both pathways, there are some pros and cons that are important to consider. Starting off with early specialization. As mentioned earlier, Ericsson et al. (1993) stated that early specialization with deliberate practice is essential to the development of expertise in any domain. They emphasized that ‘the higher the level of attained elite performance, the earlier the age of first exposure as well as the age of starting deliberate practice.’ Although it is mentioned by Ericsson et al. (1993) that deliberate practice is ‘not inherently enjoyable’, several studies reported positive feelings towards practice sessions that are aiming to improve performance (Baker & Young, 2014; Ward et al., 2007; Starkes et al., 1996). But apart from that, early specialization with deliberate practice has also been associated with negative effects. For example, Wiersma (2000) reported that early specialization could affect the long-term physical activity involvement and therefore long-term health. This could potential happen due to the limited range of skills performed caused by only practicing one sport during early specialization, which in turn could decrease the likelihood of participation in alternative physical activities. Other disadvantages found are increased dropout due to lack of enjoyment and injuries (Law et al., 2007; DiFiori et al., 2014; Dalton, 1992). But maybe even more important, the study Vaeyens et al. (2009) showed that there is not really any evidence that an early start and a high amount of deliberate practice are associated with greater success at a later stage in life.

Looking at early diversification and deliberate play there are also some pros and cons to mention. After Côté and Hay (2002) introduced the concept of deliberate play, they proposed that this play-like environment can help stimulate intrinsic motivation (Côté et al., 2003), which in turn can serve as the basis for a self-regulated involvement in elite sport at a later stage in someone’s career (Côté et al., 2009). This could arise because of the number of different physical, cognitive, affective and psychosocial environments children experience through the participation in different sports (Côté et al., 2012; Côté et al., 2009; Côté, Horton,

et al., 2009). Another benefit of early diversification is that sampling can stimulate prolonged engagement in sport by limiting physical injuries (Fraser-Thomas et al., 2005). Furthermore, the research of Bridge and Toms (2013) looked at the number of sports individuals participated in and set this against the DMSP framework (Côté, 1999; Côté et al., 2007; Côté & Fraser-Thomas, 2007). They asked participants to elaborate on their participation in sports between the ages of 7 and 18 years, including all types of sports. Things like number of sports and highest standard of competition were asked. The main sport was selected based on the one where the participant reached the highest level in. The results showed that 'individuals who competed in three sports aged 11, 13 and 15 were significantly more likely to compete at a national compared with club standard between the ages of 16 and 18 than those who practiced only one sport.' This could mean that the early diversification pathway is more beneficial to becoming expert in a sport than the early specialization pathway. But there is more evidence needed to say for sure if the early diversification pathway is superior for reaching excellence in sport. So, that is what this research is aiming to provide.

Current research

Concluding, it seems like early diversification has more advantages compared to early specialization, and therefore maybe could be the more beneficial pathway. But, Baker et al. (2009) stated some limitations of the previous studies and directions for future work. There is more research necessary to find out which pathway is more effective, and how to enhance them. One direction for future work that Baker et al. (2009) suggested is that there is more research required to determine whether the early diversification approach applies to all sport types and for all skill levels. Güllich et al., (2021) also mentioned it could be interesting to look further into the relationship between earlier participation patterns and later performance development. So, to study this topic further, and to get more specific information about the pathways, this research is aiming to provide more information on the topic of early

diversification in team sports, specifically if the amount of early diversification vs. the amount of early specialization during childhood influences the current performance level in adolescence. In more detail, this research aims to see whether there is a relation between the number of sports and amount of specialized vs. diversified practice during childhood and current performance level, and to research further if there is a difference in future level of sports performance based on the developmental pathway. Based upon the current literature like the research of Bridge and Thoms (2013), were previously has been shown that the number of sports was associated with reaching a higher level, the following hypothesis have been formulated. Hypothesis 1: A positive relation between number of sports, hours of early diversification and level of sport performance in adolescence is expected. Hypothesis 2; Athletes with less specialized- and more diversified practice hours during childhood are expected to have a higher current performance level in adolescence in their main sport.

Method

Participants

For this research, an a priori power analysis has been conducted with G*Power 3 (Faul et al., 2007). Based on an ANOVA, to get a power of 80% ($\alpha = .05$) with a medium effect size ($f = .25$), a sample size of 128 was necessary.

The participants in this research are recruited from the 'Topsport Talent School Groningen' (TTSG). This is a high school where children get more freedom to also pursue an athletic career next to their education. To get a more accurate current level of performance only participants from 14 years and older are taking part in this research. So, the choice had been made to only include the 'older' athletes that are following their education at the TTSG. Because according to the DMSP (Côté, 1999; Côté et al., 2007; Côté & Fraser-Thomas, 2007) these students are now in their specializing/investment years, so they are most likely more developed in their athletic careers, in comparison with the younger students at the TTSG.

After conducting the questionnaire at the TTSG, there were 54 participants who actually completed the questionnaire, of which 2 didn't agree with the informed consent so they were immediately removed from the dataset. To make sure that it would be as accurate as possible when comparing the participants with each other, only the participants with a team sport as a main sport have been chosen to keep in the analysis, 20 participants with an individual sport as main sport were therefore removed. The following team sports were included: acrobatic gymnastics, basketball, floorball, handball, hockey, korfbal, football, and water polo. Another participant did not fully complete the questionnaire. After removing these participants, there were 32 participants still in the dataset. The age of these participants ranged from 14 to 18 years of age ($M_{\text{age}} = 15.97$ $SD = 0.86$, 46.9% woman).

The parents of the participants all gave their permission to use their children's data for scientific research. The study was approved by the ethical committee of Psychology, University of Groningen

Procedure

The participants were scheduled to participate in this study during their normal school hours. The researcher was present during this hour to answer possible questions. They could fill in the questionnaire through a QR-code or URL that was provided by the researcher. Most of the participants used their mobile devices. After reading and agreeing with the informed consent the participants were told that they were going to be participating in this research about their sports experience during primary school and high school. This questionnaire is divided in three different parts. The goal of the first part was to collect demographical information about the participants, like gender, age and in which school year they are currently in. The second part contained questions about the participants' current sports situation. The goal of this part was to get more insight into the types of sports the participants were engaging in, how much time they practice this sport(s), and what their current level is.

Questions that were asked were for example ‘How old were you when you first started your main sport?’, ‘How many hours a week do you spend doing your main sport?’ and ‘How many months a year are you active in your main sport?’ Besides these questions, it was also important to measure the current level of the participants. To measure this, the participants were asked to rate their performance during this season in comparison with other children of the same age who play the same sport, this question was answered on a slider (0-100) (Hendriks, 2016). Finally, the last part was about the participants their sport participation during primary school. The questions in this part focused on basically the same things as the questions during the previous part, but then with the emphasis on the primary school period (age 0-12). So, what type of sports did they do during primary school, how much time did they spend doing each sport, and what was the performance level. Some of the questions were multiple choice (e.g., ‘What is your current main sport?’) and others were answered on a slider (e.g., ‘How many hours do you spend practicing for your sport each week’). To make sure the students could remember as good as possible what they did during primary school, the parents were asked in the invitation email to help their child with remembering the types of sports and hours that they spend doing these sports.

Materials

The questionnaire was completed online using Qualtrics. Some of the questions are based on the proposed interview method of Côté, et al. (2005). In this interview method, they proposed topics that should be discussed to assess ‘how elite athletes’ development may have differed from that of less accomplished athletes in the same sports and events.’ It consists of three content areas: Measures and description of current and past level of performance; engagement in domain-related activities; and factors limiting the quality and quantity of training. The questions that were used in the current questionnaire are based upon the suggested topics in the ‘Engagement in Domain-Related activities’ part. Furthermore, the

question that was measuring current level is based on the Sport report (e.g., ‘How would you rate your level compared to athletes of your age?’) (Hendriks, 2016).

Data analysis

After removing the first participants and before analyzing the data, other noticeable things in the data have been investigated. Part of the data of one participant was removed. This person included swimming lessons as one of the practiced sports during primary school, but this was explicitly mentioned not to include. This participant mentioned in the comment section that this data was included, so the choice was made to remove the answers of swimming for this participant. Six participants did not include their current main sport, which they started during primary school, in the second part of the questionnaire. To fill in this missing data, answers of the other participants with the same sports, who did answer these questions, have been used. Mean hours have been calculated based on these responses and filled in for the missing data. Furthermore, the choice had been made to only include sports that the participants practiced for half a year and longer. The data of sports that were only practiced for a few months was therefore excluded from the data analysis.

For the data analysis, different variables were used. The current performance level was used as the dependent variable. As the independent variables, the number of sports during primary education, hours of practice in main sport during primary education, hours of other sports during primary education and current weekly hours of practice have been used. Total hours of practice during primary education was calculated using the answers of the participants. Before we could test the second hypothesis, groups have been conducted for all three variables, to analyze whether significant differences exist between the groups with regard to performance level. The participants have been divided in two groups for the following three variables: 1) hours of practice in main sport during primary education (cut-off value: 1562 hours); 2) hours of practice in secondary sports during primary education (cut-off

value: 249 hours); and 3) current weekly hours of practice in main sport (cut-off value: 10,9 hours). The participants have been divided into two groups; few hours of practice and many hours of practice. The cut-off point for the groups was the median of the different independent variables. A correlation and ANOVA analyses will be run to see whether there is a relation between these variables and if differences exist between different groups based on amount of practice hours.

Results

To first get an overall look at the data and the responses the participants have given, descriptive statistics for the dependent variable and the independent variables are shown in table 1. In this table, the mean, SD, minimum and maximum for the different variables can be found.

Table 1

Descriptive statistics for DV and IV's.

Variable	Mean	SD	Min.	Max.
Current performance level (0-100)	67,78	23,74	0	100
Total number of practiced sports	2,78	2,21	1	12
Total hours of practice in main sport during primary school	1791,12	1418,84	0	5616
Total hours of practice in secondary sport(s) during primary school	429,94	613,19	0	2548
Current weekly hours of practice	11,64	5,16	5,2	28,1

Table 2 shows the descriptive statistics for the different groups that were created based on the median of the independent variables. In this table the N, mean and SD can be found for each different group, per variable.

Table 2*Descriptive statistics for the different groups.*

Variable	Group	N	Mean	SD
Total hours of practice in main sport during primary school	Less practice hours	16	696,75	545,30
	Many practice hours	16	3022,75	1108,32
Total hours of practice in secondary sport(s) during primary school	Less practice hours	16	35,00	62,35
	Many practice hours	16	824,88	663,65
Current weekly hours of practice	Less practice hours	16	8,04	1,83
	Many practice hours	16	15,83	4,93

Testing of Assumptions

Before doing the analyses, a check has been done to see whether the assumptions were met. First, the results for Levene's test for homogeneity of variance showed that there was no violation of the homogeneity assumption for the different groups ($p > .05$). Next, according to Shapiro Wilk's test, most of the data was approximately normally distributed ($p > .05$). Only for the variables hours in main sport during primary school ($p = .029$) and hours in secondary sports during primary school ($p = .047$) the groups with many practice hours were not normally distributed. Looking at the boxplots for outliers, there were two outliers in the hours of practice in main sport during primary school, three in hours of practice in secondary sport during primary school, and one in the current weekly hours of practice variable. But after further investigation it was not necessary to remove these participants. We chose to continue

with the analyses as planned, keeping the violation for the normality in those two groups in mind.

Hypothesis 1

After the overall look into the data and assumption checks, the first hypothesis has been tested. A positive relation between number of sports, hours of early diversification and level of sport performance in adolescence was expected. To test this hypothesis, correlations between the independent variables and current performance have been calculated. These calculations only showed a significant and quite high Pearson correlation for current hours of practice ($r = .440$ $p < .05$). For the other variables, the correlations were not significant and very weak. The Spearman correlation for number of sports was $r = -.106$ ($p = .564$), and the Pearson correlation for practice hours in main sport during primary education $r = -.067$ ($p = .717$) and for practice hours in secondary sport during primary education $r = .115$ ($p = .530$).

Hypothesis 2

For the second hypothesis, it was expected that athletes with less specialized- and more diversified practice hours would have a higher current performance level in their main sport. To test this hypothesis, two groups have been conducted (less hours of practice vs many hours of practice) for each variable to see whether differences exist between them with regard to current performance level. To see whether these differences would exist between these groups in current performance level, a three-way ANOVA with a 2x2x2 factorial design has been used. Result of the three-way ANOVA for the 2x2x2 factorial design showed no significant main effects for hours of practice in main sport during primary school $F(1, 24) = .115$, $p = .737$, with a small effect size (partial $\eta^2 = .005$), for hours of practice in secondary sports during primary school $F(1, 24) = .155$, $p = .697$, with a small effect size (partial $\eta^2 = .006$) and for current hours of practice in main sport $F(1, 24) = .175$, $p = .680$, with a small effect size (partial $\eta^2 = .007$).

Discussion

The aim of the current study was to gather more information on the topic of early diversification vs. early specialization and to see whether there is a relation between the followed pathway during childhood and level of performance in adolescence. Participants from the TTSG filled in an online questionnaire about their athletic careers so far. Information about number and type of sports, amount of practice hours, and level were asked for the period during primary education (age 0-12) and current time. The results are based on the current level, amount of practice hours during primary education and in the present time. The first hypothesis was that there would be a positive relation between number of sports, hours of early diversification and level of performance in adolescence. The results showed no significant very low correlations for these variables. Some correlations were even slightly negative. This could mean that, based on this sample, there would be no relation between the number of hours' early diversification vs. early specialization during childhood and performance level in adolescence. It could even look like there is a negative relation between number of sports and current performance level, but this correlation was also very low and non-significant. Furthermore, looking at the results for this sample, it would even suggest that sport participation during childhood does not matter at all for performance level in adolescence. This is very unexpected based on everything we know so far about early specialization vs. early diversification. Ericsson et al., (1993) stated for example that it is essential to have an early start in one sport and maximize deliberate practice from a young age. On the other hand, for the early diversification pathway, Bridge and Toms (2013), did find a positive relation between number of sports and performance level. Also, Côté and his colleagues repeatedly found that engagement in deliberate play during childhood is essential for developing fundamental skills and eventually reaching excellence (Côté 1999; Côté et al., 2001; Côté & Hay, 2002). There only was a significant, medium positive correlation between

current hours of practice and current performance level. This is in line with many of the previous done studies (e.g., Baker et al., 2005; Hodges et al., 2004; Law et al., 2007). Before looking at possible explanation for these non-significant findings, we first will interpretate the results for the second hypothesis.

For the second hypothesis, it was expected that athletes with less specialized- and more diversified practice hours will have a higher current performance level in their main sport. The results of the three-way ANOVA showed no significant main effects for hours of practice in main sport and hours of practice in secondary sport during primary education. This would suggest that there is no difference between the groups that had less or many hours of specialized or diversified practice during childhood, in current performance. It also showed no significant difference between having less or many weekly practice hours in the present time in current performance level. Which in turn could mean that there is no difference between the group that currently practices less hours and the group that practices more hours in current performance level. Which is especially remarkable, because of the significant positive correlation found between current practice hours and current level in adolescence in the first hypothesis. So, this would mean that there is a relationship, but you cannot divide the group into less vs. many hours and see a significant difference in performance level during adolescence. All of these results are again unexpected. For example, when looking at meta-analysis of Güllich et al. (2021), they did find a difference between senior-world class athletes and national-class performers in accumulated practice hours in the main sport. Besides that, they also found that senior world-class performers were involved in more coach-led practice in other sports besides their main sport during childhood. Another study showed that international medalist practiced more in other sports before entering their main sports and maintained this engagement in other sports over more years compared to non-medalists

(Güllich, 2016). So, how come did this research not find any similar results? There could be a few possible explanations for these non-significant findings.

First and foremost, this study had a sample size of 32 in the end. According to the a priori power analysis, a sample size of 128 was necessary. So, the sample size of this study was a lot lower than the recommended sample size, which could lead to a decreased statistical power. We still continued with this study because of the type of sample we have. These participants are recruited from the Topsport Talent School, a school where students get more freedom so that they can also focus on their athletic careers. This means that all the participants are athletes who chose to adjust their education to their athletic careers. Therefore, it is a smaller population, and more difficult to find a lot of participants for a bigger sample. But because of this huge difference in sample size, it is important to take caution when drawing conclusion out of this data.

Another possible explanation could be that it was difficult for the participants to accurately recall their sport participation during primary school. Research previously showed that accuracy in recall is greater in different occasions; when the recall period is shorter, when the recall activity concerns something that is important to the individual and when the recall behavior is constant over a period of time (Dex, 1995; Bound et al., 2001). It has been previously shown that hours of practice in previously played sports are recalled with a moderate to poor consistency (Wilson-Hopwood et al., 2011). However, our results are mostly based on these recalled hours of practice. Looking at our participants, the way the questionnaire was structured, and on which data the results are based, it could therefore be a possibility that sport activities that participants engaged in during their first years of life were not that salient to them, and therefore could result in a recall error and inaccurate responses. Which on the other hand could also be an explanation for the positive relation found between current hours of practice and current level. Because this recall period is very short, and the

main sport is currently important and salient to the participants, the recall error is probably very small. We tried to overcome this by asking the parents to help the children remember, through talking about the sports they did with them, but we do not know for sure if the parents actually did that.

Lastly, the age of the participants ranged from 14 till 18 years. According to the DMSP, children with the age of 14 and 15 are still in their specializing years and not yet in their investment years (Côté, 1999; Côté et al., 2007; Côté & Fraser-Thomas, 2007). This could mean for this part of the participants, that they probably did not reach their full potential yet because they are simply just too young to be there already. They are still in the middle of their athletic careers. Olympic athletes have been found to start training competing and participating in international championships significantly later (Vaeyens et al., 2009). Also, Balyi and Hamilton (2004) found that reaching an elite level in sports in which peak performance is reached after maturation is not hindered by early diversification. The age of peak performance can differ for different types of sports. Longo et al. (2016) investigated the age of peak performance in Olympic sports. For the team sports we also have in our sample, they found that the peak performance age ranged from 26.9 to 29.2 for men in water polo, basketball and hockey, and from 29.5 to 32.6 for handball. For women these ages ranged from 23.8 to 25.3 for water polo, from 25.8 to 27.3 for hockey, and from 27.5 to 30.2 for football and handball. So, for our participants, whose mean age was 15.97, there is still a lot of time to reach their full potential. Therefore, there is a high chance that the current performance level they filled in, is not their potential performance. This could be a reason why we do not see any significant results for our sample. To overcome this, we already chose the oldest group of the students available, but to totally overcome this, more research should be done when the students are fully matured or finished with their athletic careers to know for sure what their highest reached level was.

Limitations and future research

When interpreting the results, there are some important limitations to keep in mind. First one being the way the questionnaire was structured. We only measured amount of practice hours during primary school on one variable. This means, we only had one question per sport for this variable (e.g., ‘How many hours did you spend practicing for this sport each week?’). The participants could only fill in one answer for their entire primary school period. But it is very likely that when someone practices, for example, 6 hours a week when they are 11, that they did not practice that many hours immediately when they started the sport at, for example, age 4. But because we only asked for one answer over this entire period, they had to provide us with one mean number of hours over this entire period of time. This could result in a bias for the amount of practice hours. To overcome this, future research could choose to measure sport participation at different ages and on six different variables as suggested by Güllich et al. (2021). They said that participation in sports is characterized by six variables: age at which they started their main sport, rate of early progress, amount of main-sport coach-led practice, amount of main-sport youth-led play, amount of other-sports coach-led practice, and amount of other sports youth-led play. Using these variables, and measuring them for each year they practiced a certain sport, could give more accurate results.

Another limitation which could result in less reliable measures, is that the questionnaire has been filled in in a busy classroom. As previously mentioned, the participants had time scheduled during their normal school day to fill in the questionnaire. They had half an hour in their schedule where they were in the classroom with each other and there they could answer the questions. Because they were with their usual peers, there was a lot of noise in the classroom. Participants were chatting with each other about the questions and their sport experiences because of this free environment. Besides that, for the participants who did a lot of sports during primary school, the questionnaire was quite a bit longer, thus

the participants finished at different times, which also led to a distracting environment for the participants who did not finish yet. A study of Forrin et al. (2021) found that distractions can cause inattentiveness to spread from one student to another. This could have resulted in less focus on the questionnaire which in turn could have led to less accurate and reliable answers. To avoid this in the future, a separate room with less distractions can be created where participants can fill in the questionnaire in silence and therefore can focus better on the questions.

For future research, a suggestion would thus be to measure amount of practice during childhood on different variables suggested by Güllich et al. (2021) and for more periods in time. Furthermore, it could be interesting to follow the athletes for a longer period and ask the same questions again when they fully matured and reached their full potentials in their athletic careers. In this way, you can really see whether the amount of accumulated practice hours within a certain pathway was predictive for their final reached performance level. Besides that, for this research we only looked at athletes with a team sport as their current main sport and compared those with each other. It could also be interesting to see whether there would be differences within all those types of team sports. It could be beneficial to know per sport what could be the best pathway to success. Apart from that, it is also of interest to take individual differences into account, what road works for one kind of individual may not work for another. Scientist can take a deeper look into different personalities and what would be beneficial for them. When that knowledge is available, athletes and coaches can map out a very specific road to hopefully reach excellence more efficiently in the future.

Conclusion

In conclusion, the aim of this research was to see whether there is a relation between the developmental pathway and current performance level, and to see whether there exists a difference in level of sports performance in adolescence based on the developmental pathway.

The results did show a positive relation between current practice hours and current level, but no relation was found for amount of early diversification vs. early specialization and current performance level. Besides that, this research also showed no prove that there is a difference between groups who have a lot- vs. less diversified practice during childhood in current performance level. Though this research provided no significant results, it is still important to investigate the pathways more extensively. Current literature is still somewhat contradictory, it seems like the early diversification pathway is showing more advantages compared to early specialization and therefore being the more beneficial pathway. However, looking at the current research, it did not fit in with that view, but this could also be because of the limitations stated above. Furthermore, it is always important to keep in mind the individual differences and preferences that exists between athletes. The career that led one athlete to the top, does not necessarily need to lead another athlete to reaching the same level. If we want to improve the talent development of promising athletes, it is very useful to know what, per sport and per athlete, could be the most efficient way to reach excellence with as less as possible setbacks.

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