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Team Sports and the Theory of Deliberate Practice

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Two studies tested the theory of deliberate practice (Ericsson, Krampe, & Tesch-Romer, 1993) and contrasted results with the sport commitment model (Scanlan, Carpenter, Schmidt, Simons, & Keeler, 1993a, 1993b). In Part I, international, national, and provincial soccer and field hockey players recalled the amount of time they spent in individual and team practice, sport-related activities, and everyday activities at the start of their career and every 3 years since. In Part II, these activities were rated in terms of their relevance for improving performance, effort and concentration required, and enjoyment. A monotonic relationship between accumulated individual plus team practice and skill level was found. In contrast with Ericsson et al.'s (1993) findings for musicians, relevant activities were also enjoyable, while concentration became a separate dimension from effort. The viability of a generalized theory of expertise is discussed.

Keywords: team sports, expertise, deliberate practice, activity dimensions

A substantial body of evidence suggests that elite performers require more than 10 years of practice to acquire the necessary skills and experience to perform at an international level. This 10-year rule was first discussed by Simon and Chase (1973), and has held up in many of the domains investigated: chess (Charness, Krampe, & Mayr, 1996), sports (Bloom, 1985; Ericsson, 1990; Ericsson, Krampe, & Tesch-Romer, 1993; Schulz, Musa, Staszewski, & Siegler, 1994; Starkes, Deakin, Allard, Hodges, & Hayes, 1996) and music (Bloom, 1985; Ericsson et al., 1993).

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In music, Ericsson, Krampe, and Tesch-Romer (1993) have collected detailed diaries of daily activities of expert pianists and violinists. Using retrospective recall from the beginning of practice, the authors were able to estimate each musician's amount of accumulated practice at each age. Violinists typically began practice between ages 4 and 5. By age 20 the best performers had spent over 10,000 hours in what they termed *deliberate practice*, an intermediate group had put in 8,000 hours, and the least accomplished group only 5,000 hours. Patterns emerged indicating that level of performance attained was monotonically related to accumulated practice.

Ericsson et al. (1993) subsequently presented a very environmentalist theory, known as the *theory of deliberate practice,* in which talent plays no role in the development of expertise. Beyond the monotonic relationship between practice and performance, they suggest that deliberate practice is an effortful activity motivated by the goal of improving performance. It is not watching the skill being performed, not inherently enjoyable, does require effort and attention from the learner, may involve activities selected by a coach or teacher to further learning, and (unlike work) does not lead to immediate social or monetary rewards. The theory of deliberate practice and critiques of it are presented elsewhere (Ericsson, 1996; Ericsson & Charness, 1994; Ericsson, Krampe, & Tesch-Romer, 1993; Lehmann & Ericsson, 1996). It is important to note that while this theory was not developed on the basis of sport research, Ericsson on many occasions[1] and in several publications[2] has used sport examples and sport research by others to infer that the theory of deliberate practice might well apply to expertise in sport.

Within the sport psychology literature another very important theory is the *sport commitment model* (Carpenter, Scanlan, Simons, & Lobel, 1993; Scanlan et al., 1993a, 1993b). Since the actual staying in sport (and by inference the continuance of deliberate practice) is a consequence of this commitment, it is important to consider the proposed sources of such commitment. This model suggests that commitment to sport is a function of several independent factors: sport enjoyment, involvement alternatives, personal investments, social constraints, and involvement opportunities. Two large tests of the model with young athletes demonstrated that sport enjoyment, personal investments, and, to a lesser extent, involvement opportunities are the most salient factors, with more than 68% of commitment variance explained (Scanlan et al., 1993b; Carpenter et al., 1993). The types of investments that have proven most important to commitment are of personal time and effort. Of course, it is only with continued commitment that international athletes emerge. With deliberate practice it follows that the consequence of this commitment is increased number of hours practiced per week as one's career progresses, and more effort put into activities related to performance.

Interestingly, in a postscript to the first major test of the sport commitment model, the authors suggest that while the antecedents of sport commitment are well represented by the factors in their model, the consequences (such as actual persistence) are not. They go on to suggest that the consequences of sport commitment "provide fertile ground for an enormous amount of research" (Carpenter et al., 1993, pp. 130). This paper focuses on the changing nature of practice that accompanies such persistence in sport.

Across models, the personal investment of time and effort is seen as an important predictor of commitment by Scanlan, and the result of that commitment by Ericsson. It is also noteworthy that while Scanlan and colleagues consistently point out that enjoyment of sport is critical to commitment, Ericsson and colleagues

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suggest that deliberate practice is not inherently enjoyable. Since the majority of time in sport is spent in training and a lesser amount in actual performance, on this point it is difficult to reconcile the theories. Either Ericsson's theory underestimates athletes' enjoyment of practice, or the enjoyment of sport seen by Scanlan comes primarily from performance and not practice.

Part I of each study investigates whether for team sports the relationship between practice and performance is monotonic. Part II examines the underlying dimensions of practice to determine whether, as Ericsson would suggest, practice is always relevant, effortful, and not inherently enjoyable. To date the theory of deliberate practice has been tested only with regard to individual skills (i.e., chess, music, wrestling, figure skating). This paper examines the viability of the theory for the team sports of soccer and field hockey.

Sport-Related Evidence for Deliberate Practice

For individual sports the monotonic relationship between accumulated practice and performance attained, predicted by the deliberate practice theory, has been found. The career practice patterns of international and club-level athletes in wrestling (Hodges & Starkes, 1996) and figure skating (Starkes et al., 1996) have been studied. Wrestlers typically begin practice around 13 years of age, adopt more systematic practice with a coach at 14, and practice on a year-round basis at 16 years. Both retired international and club-level athletes report that the peak of their career was around age 25, which would mean roughly 12 years of practice to career peak. Figure skaters begin at 5 years, begin private lessons at 7, and begin skating year-round at age 10. The average age of national team members, all of whom were international performers, is 21 years. Thus they have had 16 years practice on average.

When data from Ericsson's violinists and pianists are graphed along with data from wrestlers and figure skaters, the results are remarkable in similarity (Starkes et al., 1996). Despite varying starting ages, the relationship from beginning of practice to a maximum of 15 years from start of career is monotonic in every domain. In a comparison of club vs. international wrestlers there was no significant difference between groups over the first 5 years of practice, but differences began to emerge in amount of practice by year 6 and increased thereafter. In wrestling for example, by age 20 the international wrestlers had accumulated over 1,000 hours more practice than club-level wrestlers.

Issues with regard to what constitutes deliberate practice have begun to emerge in the sport research. Contrary to the findings of Ericsson et al. (1993), practice alone did not differentiate between skill level of wrestlers; however, practice with others did. Thus, even within an individual sport it is necessary to extend the notion of what constitutes deliberate practice.

The Role of Deliberate Practice in Team Sports

In team sports much of practice is coach-determined. This is true both in terms of the absolute amount of time put in and which skills are actually practiced. As a result, we might predict that absolute amount of accumulated practice might be less predictive of any one individual's performance attained. This could also be

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because a certain percentage of practice must be devoted to the lowest or highest common skill denominator within a team, not necessarily the skill that would most benefit each individual.

A second issue with team sports is consideration of what constitutes deliberate practice. In the context of team sports we have elected to consider individual practice and team practice as two possible forms of deliberate practice. These have been considered separately because the relative contribution of each is likely to change over the course of an athlete's career, or even over a competitive season.

A third issue addresses the underlying nature, history, and type of team sports chosen. The two team sports selected in this paper represent two extremes in terms of history, opportunities for athlete advancement, and traditional status in the sporting community. Within the European context soccer is a traditional, highly organized, professionally driven system, where athletes have the opportunity to advance to professional teams and play year-round in a highly competitive environment. Field hockey is a sport with much less spectator support, and no professional system in Europe.

The Reliability of Retrospective Recall of Practice

Much of our knowledge about creative expertise and exceptional individuals suffers from the biases of gathering information retrospectively. This is because many personal accounts from experts are acquired years or decades after they have been recognized by their peers and society as exceptional individuals (Ericsson & Charness, 1994; Gruber, 1981). One of the arguments favoring the accuracy of recall for expert musicians and athletes, however, is that practice has constituted such a large part of their lives and daily routines that specifics about practice are readily recalled. In sport as well, daily practice is usually scheduled and planned by a coach. This means that the scheduled hours of practice often remain the same over one or more years. It also offers one means of corroboration of recall data from a second individual, the coach.

One way of checking recall reliability has been to have subjects first recall their practice activities from the beginning of their career to present, next to recall their specific practice activities from a recent typical week, and finally, complete a 1-week diary in which all of their activities for the week are recorded. The assumption has been that the data from the recent typical week should correlate with the most recent year of practice. The second assumption is that data from the diary week should correlate strongly with that from the most recent typical week and correlate with estimates of weekly practice over the most recent year. These are the forms of reliability checks used to date.

In all of Ericsson's and Starkes' studies, both musicians and athletes have tended to overestimate practice time when retrospective estimates were compared with actual practice time spent during the diary week. For example, international wrestlers' practice with others yielded a correlation ($r = .66$, $p < .05$) between estimates for a recent typical week and data from a diary kept for 1 week. Correlations from the typical week to diary week for strength training with others ($r = .98$), strength training alone ($r = .96$), and attending wrestling practice ($r = .76$) were even higher. So, while international wrestlers estimated they spent an average of 15.2 hr/week in practice over the past year, and 17.6 hr/week practicing during a recent typical week, during the diary week they actually practiced only 11.4 hr.

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Several factors potentially may explain these discrepancies. First, as Ericsson et al. (1993) suggest, it may be that both athletes and musicians recall the amount of time they aspired to practice, as opposed to what they actually did. Another suggestion is that the daily routines of international-level performers are by necessity much more structured, because of the time demands of increased practice, and as such are easier to recall than for lower-skill performers. Stage of the season in which the diary is completed may also influence results.

The methods of evaluating reliability in the present studies go beyond those used to date and introduce additional new test forms. First, for the soccer study (as in the studies of music and wrestling) a 1-week diary study was conducted with 6 randomly selected subjects from each skill group. This technique provided a reliability measure of the week's activities in comparison to weekly averages for the current year's training. Second, the retrospective questionnaire was also administered on a second occasion to 10 randomly selected soccer players. This was the first time test-retest reliability has been assessed. Third, subjects were contacted once again 6 months after the completion of the diary study, and completed both the biographic information and career retrospective. This provided another measure of test-retest reliability of recall.

Finally, in the field hockey study a confidence estimation technique proposed by Pedhazur and Schmelkin (1991) was used. Subjects provided an estimate of their confidence in recall for time spent in individual and team practice, sport-related activities, and everyday activities. This allowed comparisons of recall confidence according to the athlete's skill level and type of activity recalled. In total, four different measures of reliability were employed.

Part II: The Relevance, Effort, Enjoyment, and Concentration Required by Various Activities

Part II of each study examined what athletes say about the relevance, effort, enjoyment, and concentration associated with practice, leisure, and everyday activities. In Ericsson et al.'s (1993) original studies, violinists and pianists of varying skill levels were given two activity taxonomies detailing musical and everyday activities, and were asked to rate each activity in terms of its relevance to improving performance, effort required to perform the activity, and enjoyment. Their basic finding was that activities related to practice alone were rated most relevant, and most effortful, but were not inherently enjoyable.

In sport it has proven important to separate the constructs of physical effort and mental concentration. In the original music studies this distinction was not made, but in studies of wrestling and figure skating (Hodges & Starkes, 1996; Starkes et al., 1996), athletes were readily able to separate those activities they perceived as requiring high effort vs. concentration. For example, running was seen as highly effortful yet required little concentration. Mental imagery, while not effortful, required high concentration. Starkes et al. (1996) concluded that this is an important distinction when one tests the theory of deliberate practice in the domain of sport.

What emerges from the sport studies to date is a picture of athletes who enjoy working with a coach, enjoy those on-ice and on-mat activities most related to actual performance, see mental training and video analyses as difficult from the perspective of concentration, and, finally, see rest as necessary and enjoyable. These

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results fit well within the sport commitment model (Scanlan et al., 1993a, 1993b) and help explain why athletes would want to put in the long hours of practice required; they do not fit well within Ericsson's definition of deliberate practice (Ericsson et al., 1993). Recall that Ericsson et al.'s (1993) three criteria for deliberate practice occurred when a practice activity was "rated very high on relevance for performance, high on effort, and comparatively low on inherent enjoyment" (p. 373). For musicians, deliberate practice equated with "practice alone." From the wrestling and figure skating results, however, all practice activities seen as highly relevant were also enjoyable. In both sports, practice activities that were highly relevant also required effort. Since Ericsson's term *effort* in music is likely more related to the term *concentration* in the sport studies, it was not surprising that the top two practice activities for relevance also required high concentration.

Part II of the present studies examined the same task dimensions of relevance, effort, enjoyment, and concentration, but within the team sports of soccer and field hockey.

STUDY 1: SOCCER

Method

Participants

Three groups of male soccer players voluntarily participated in the first study. They were all players in Belgian soccer leagues. The international players ($n = 17$) were all professional players in the first division. Most of them ($n = 12$) were selected for the World Cup 1994 in the United States. The national players ($n = 21$) played in the first and second division and were all involved semiprofessionally in soccer. The provincial players ($n = 35$) performed in the third and fourth division. The mean current ages of the three groups were international, 25.6 years; national, 24.0 years; and provincial, 25.4 years.

Procedure

For Part I, all participants received a questionnaire asking them to reflect on their careers and recall their past amounts of practice, other soccer-related activities, and everyday activities.

In Part II of the questionnaire, players were asked to rate each activity within the following categories on four dimensions; they were asked to rate for relevance to improving soccer performance, effort required to perform the activity, enjoyment derived from the actual activity, and concentration required to perform the activity.

The Questionnaire

As in Hodges and Starkes (1996), the first section of the questionnaire asked for biographical information concerning the age when practice was first initiated, the highest level attained in soccer, success in competitions, and the number of coaches. This first part was followed by four sections that required subjects to think back to the amount of time they had spent practicing for soccer: individually and in team practice, in soccer-related activities, and in everyday activities during a typical week. A taxonomy of the various activities is illustrated in Table 1. Subjects

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Table 1 Taxonomy of Various Activities Related to Individual Practice, Team Practice, Sport-Related, and Everyday Life

Activity	
Individual practice	*Team practice*
Weights	Games and tactics
Flexibility	Technical skills
Running	Weights
Game video analysis	Running
Coach alone	Flexibility
Technical skills**	Swimming
Cycling*	Cycling*
Tennis**	
Sport-related	*Everyday life*
Reading	Sleep
Journal	Study
Mental imagery	Active leisure
Watching sport	Work
Professional conversation sport	Nonactive leisure
Coaching	

Note. *Specific to soccer alone; **specific to field hockey alone.

were required to estimate the number of practice hours since beginning soccer to the present time, at 3-year intervals. A list of activities then followed, which included typical activities encompassed by each of the four sections. These activities were determined after consultation with professional soccer coaches. In Part II of the questionnaire, athletes were asked to rate each of the activities on four dimensions (from 0 to10, where 0 was low and 10 was high). They were asked to rate for relevance to improving soccer performance, effort required to perform the activity, enjoyment derived from the actual activity, and concentration required to perform the activity. Subjects were also required to recall the duration of their off-season for every 3-year interval throughout their careers.

Reliability

As in Hodges and Starkes (1996), the validity and reliability of the questionnaire was examined by comparing retrospective estimates with those reported in a detailed diary kept for a 7-day continuous period. Six randomly selected subjects in each group were asked to keep a detailed diary for one week. They were asked to be as detailed as they saw necessary and to be specific as to whether the activity was performed alone or with others. Subjects were asked to fill out the diary sheet at the end of every day before going to bed, and to be consistent with this procedure. Seven 24-hour diary sheets were provided that were divided into 15-min sections. An example then followed of how the diary was to be completed. At the end of the 7-day period, subjects were asked to rate whether this was a typical

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week. The original questionnaire was given just after the beginning of the competitive season, followed by the diary. The time interval between the completion of the questionnaire and the diary study was 1 month to avoid seasonal variations in practice activities.

As another means of assessing test-retest reliability of retrospective recall across a career, 10 other subjects, randomly selected across groups, were asked to fill in the whole questionnaire a second time, 6 months later.

Data Analyses

For Part I the data were analyzed as a function of the number of years players had been involved in practice alone (or individual practice), practice with others (or team practice), and soccer-related activities. The mean data were analyzed in a split-plot factorial 3.7 ANOVA including three skill levels (international, national, provincial) and seven probes of years into career (start = 0, 3, 6, 9, 12, 15, 18 years).

To provide a comparison to both Ericsson et al.'s (1993) data on musicians and Hodges and Starkes' (1996) data on wrestling, accumulated amount of practice was examined as a function of the number of consecutive years involved in soccer. For each athlete, line graphs were used to estimate the number of hours spent in both individual and team practice in the intervening years. Thus, data were available from the start of practice, for every year until the present (or end of career). To calculate cumulative practice hours, the hours per week were multiplied by 52 for each year, and then reported hours spent in off-season weeks (6 hr, on average) were subtracted from these estimates. In estimating length of off-season, attempts were made to be conservative such that its length was never underestimated. The mean data were analyzed in a split-plot factorial 3.19 ANOVA including 3 skill levels (international, national, provincial) and 19 probes of consecutive years into career (from start to 18 years of practice).

For all of these analyses, the sources of any significant effects were identified through Scheffé post hoc procedures. All statistical tests were completed with alpha set at $p < .05$.

For Part II, the ratings for each activity were analyzed separately to determine if the international, national, and provincial soccer players were rating differentially, which could account for their allocation of time to various activities. Similarly to Hodges and Starkes (1996), no interactions were found between skill level and the ratings given. Therefore, due to the high similarity in the way the activities were rated by all soccer players, further analyses were collapsed across groups. For each rating, a mean was calculated and compared to the overall mean for all of the activities. Statistical significance was determined using adjusted alpha levels according to Bonferroni's method (alpha was divided by 24, the number of activities).

Results: Part I

Biographic Information

All groups began playing soccer ($M = 5.5$ years $\pm$ 0.3) and engaged in team practice ($M = 7.1$ years $\pm$ 0.3) at similar ages, on average 2 years after starting. Both the international ($M = 13.3$ hr $\pm$ 2.5) and national ($M = 9.9$ hr $\pm$ 1.9) groups

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reached their peak in accumulated practice (individual plus team practice) at 15 years into career (20 years of age). Provincial players reached their peak ($M = 6.9$ hr $\pm$ 2.2) at 6 years into career (11 years of age).

Retrospective Estimates Over the Soccer Players' Careers

Individual Practice. The analyses of individual practice data showed both significant main effects of skill ($F(2, 70) = 9.32$, $p < .001$) and years into career ($F(6, 420) = 102.14$, $p < .0001$). The skill $\times$ years into career interaction was also significant ($F(12, 420) = 3.25$, $p < .001$). This interaction and subsequent post hoc tests are highlighted in Figure 1.

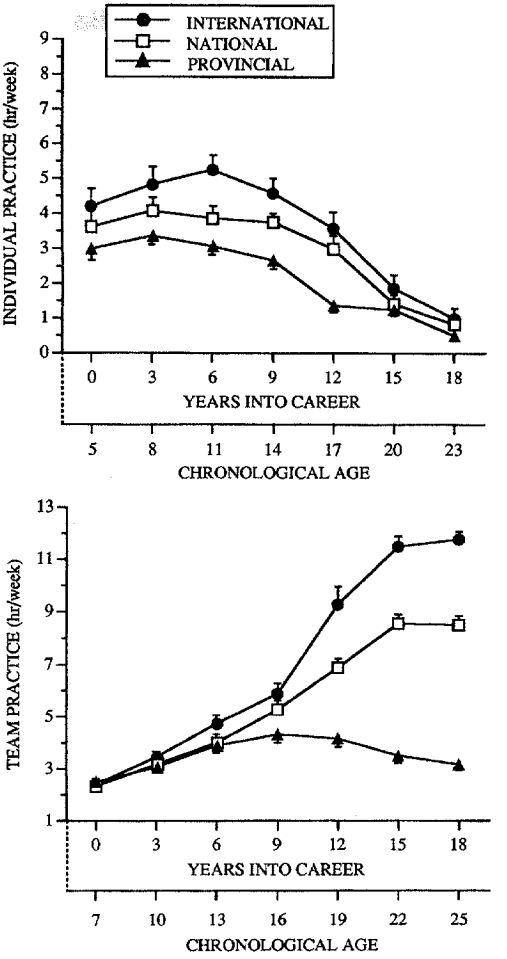

Figure 1—Mean hours per week (and standard errors) spent in individual practice and team practice as a function of the number of years into soccer career and chronological age.

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Across skill level, at 6 years into career there was a significant difference between international ($M = 5.2$ hr/week) and provincial players ($M = 3.1$ hr/week). Across years into career, there was a significant decrease in individual practice for international players from 12 ($M = 3.6$ hr/week) to 15 years ($M = 1.8$ hr/week). After 15 years into career the group differences disappeared.

Team Practice. The analyses of team practice data showed significant main effects of both skill ($F(2, 70) = 63.32$, $p < .0001$) and years into career ($F(6, 420) = 237.81$, $p < .0001$). The skill × years into career interaction was also significant ($F(12, 420) = 66.24$, $p < .001$). This interaction and subsequent post hoc tests are highlighted in Figure 1.

Significant differences between each skill level were shown from 12 years into career onward (international, $M = 9.2$ hr/week; national, $M = 6.9$ hr/week; provincial, $M = 4.1$ hr/week). Across years into career, team practice only increased significantly and progressively for the international players from 9 ($M = 5.9$ hr/week) to 12 ($M = 9.2$ hr/week) to 15 years ($M = 11.5$ hr/week).

Accumulated Practice. The analyses of accumulated practice data showed significant main effects of both skill ($F(2, 70) = 20.34$, $p < .0001$) and years into career ($F(18, 1260) = 1453.33$, $p < .0001$). The skill × years into career interaction was also significant ($F(36, 1260) = 48.47$, $p < .0001$). This interaction and subsequent post hoc tests are highlighted in Figure 2.

Across skill level, there was at 10 years into career a significant difference between international players ($M = 4587$ hr) and provincial players ($M = 3306$ hr). Significant and progressive differences according to each and every skill level were shown from 13 years into career on (international, $M = 6328$ hr; national, $M = 5220$ hr; provincial, $M = 4081$ hr).

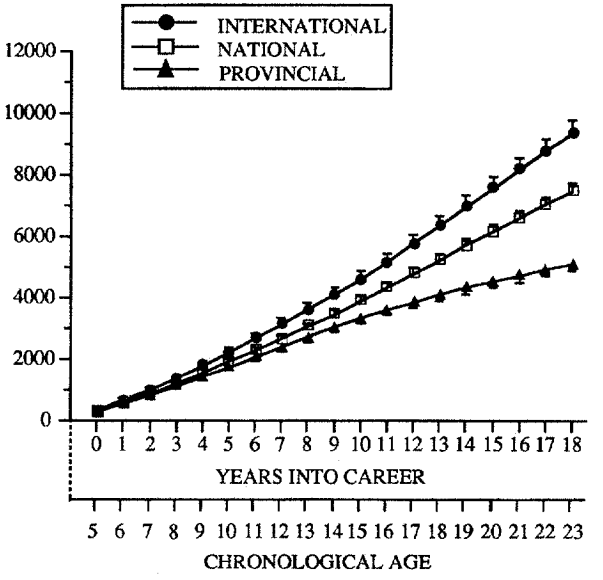

Figure 2—Accumulated practice hours (and standard errors) as a function of the number of years into soccer career and chronological age.

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At 18 years into career, international, national, and provincial players had accumulated 9332, 7449, and 5079 practice hours, respectively.

Reliability

Because participants were required to report the amount of time they had engaged in soccer-related and everyday activities, it was possible to look back at the retrospective estimates given and compare their estimates for the most recent year with those reported in the diaries. When the diary data and retrospective estimates were correlated for individual practice, team practice, and soccer-related activities, the Pearson Product Moment correlations were as follows: international level, $r = .89$, $n = 6$, $p < .05$; national level, $r = .94$, $n = 6$, $p < .05$; provincial level, $r = .84$, $n = 6$, $p < .05$. In each case retrospective estimates slightly overestimated practice in comparison with diary reports.

The test-retest reliability for individual plus team practice was of the same order: $r = .93$, $n = 10$, $p < .05$. Collapsed across career, players estimated they spent 8.5 hr/week when assessed the first time but only 8.0 hr the second time.

Results: Part II

Evaluations for the Soccer-Related and Everyday Activities

Table 2 displays the means for the various sections collapsed across groups. Responses were very similar across skill groups; as a result, a decision was made to collapse across groups. The resultant responses are therefore representative of soccer players ranging in skill from provincial to international level. Within the table, those activities that were rated significantly higher than the overall mean are denoted by an *H*, and those that were lower than the overall mean are denoted by an *L*.

Individual Practice. The two activities with significant and high ratings for relevance were individual training with the coach and running. However, whereas training with the coach also received a significantly high rating for concentration, the rating for running was significantly lower than the overall mean. Although none of the activities were rated as significantly more effortful than the overall mean, running and weights received the highest ratings for this evaluation.

Team Practice. Running was also given a significantly high rating for relevance within the team practice. Games and tactics and technical skills were also rated significantly high for relevance. As before, running, unlike games and tactics and technical skills, did not receive a significantly high rating for concentration, but did for effort. Interestingly, games and tactics and technical skills were also the only activities to receive significantly high ratings for enjoyment.

It is noteworthy that the two activities that were rated significantly lower than the overall mean for relevance, swimming and cycling, were also rated significantly lower than the overall mean for concentration. As with individual practice, both weights and flexibility training were not judged to be relevant to improving performance.

Soccer-Related. None of the soccer-related activities were judged to be highly relevant to improving performance or require a high amount of effort. Watching soccer was given a high rating for enjoyment, whereas reading soccer-related material was given a significantly low rating. The only activity to be given a significantly high rating for concentration was coaching soccer.

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Table 2 Evaluations for Various Activities Related to Individual Practice, Team Practice, Soccer-Related, and Everyday Life Across Groups

	Relevance	Effort	Enjoyment	Concentration
Individual practice				
Weights	6.44	6.68	5.12	5.24
Flexibility	6.04	6.04	4.36	5.00
Running	7.64^{H}	6.92	4.76	3.64^{L}
Game video analysis	4.92	2.76^{L}	7.00	6.72
Cycling	4.28	4.88	6.12	3.44
Coach alone	8.28^{H}	4.56	7.08	7.40^{H}
Team practice				
Games & tactics	8.18^{H}	4.18	9.20^{H}	7.74^{H}
Technical skills	8.00^{H}	4.77	8.29^{H}	8.42^{H}
Weights	5.66	6.83	4.87	6.02
Running	7.50^{H}	7.30^{H}	5.00	4.46
Flexibility	5.96	5.77	5.00	4.96
Swimming	3.33^{L}	5.91	5.41	3.70^{L}
Cycling	2.87^{L}	5.04	5.63	3.80^{L}
Soccer-related				
Reading	4.46	6.50	3.83^{L}	6.66
Journal	3.30^{L}	4.33	6.08	5.25
Mental imagery	5.72	5.20	5.24	6.96
Watching soccer	5.68	3.24	7.48^{H}	5.92
Pro. conv. soccer	5.20	4.96	6.12	5.48
Coaching	6.47	6.21	7.30	8.08^{H}
Everyday life				
Sleep	7.50^{H}	1.11^{L}	8.10^{H}	1.11^{L}
Study	4.68	7.98^{H}	2.72^{L}	8.62^{H}
Active leisure	5.96	4.61	7.88^{H}	8.62^{H}
Work	3.68	6.22	5.13	7.00
Nonactive leisure	4.80	2.63^{L}	8.18^{H}	3.40^{L}
Means	5.69	5.19	6.23	5.74

Note. 0 = low; 10 = high.

Everyday Life. Not surprisingly, sleep, active leisure, and nonactive leisure received significantly high ratings for enjoyment, but only sleep received a significantly high rating for relevance. Sleep was also rated low for effort and concentration compared to study and active leisure which were judged to require a high degree of concentration. These ratings of everyday activities were as expected, that is, high in enjoyment, with concentration depending on whether the activity was active rather than passive.

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Discussion

In the first study, soccer players began practicing at 5 years of age, much earlier than the 8 years noted for musicians (Ericsson et al., 1993) and 13 years found for wrestlers (Hodges & Starkes, 1996; Starkes et al., 1996). Both for the international and national players, the difference between the starting ages and current peaks in individual plus team practice averaged 15 years.

Retrospective recall of practice did differentiate between soccer players of different skill levels. For individual practice, however, differences between skill levels were rather limited. Especially for international players, a significant decrease from 12 to 15 years into career was rather surprising. Significant differences were found for team practice between every skill level from 12 years into career onward. As a consequence, there were significant differences for accumulated practice between every skill level from 13 years into career onward. These data suggest it is necessary to include both individual and team practice data as components when calculating accumulated practice, but this runs contrary to Ericsson's definition of deliberate practice.

Crossing domains, accumulated practice estimates at 13 years into career for the international soccer players were similar to results at 10 years into career for Ericsson et al.'s (1993) best violinists and Hodges and Starkes' (1996) most skillful wrestlers (soccer players M = 6328 hr, violinists M = 6351 hr, wrestlers M = 5865 hr). Recall that it was predicted beforehand that hours in sport might be lower because of the constraints of facility availability, or access to training partners. This was especially surprising because off-season time was taken into account when the yearly amounts of practice were estimated and likely lead to more conservative estimates of accumulated practice than those of Ericsson et al.

It is important to consider what the data on career practice patterns could potentially mean for training. With reference to practice, it may be recommended that players are provided with more opportunities to practice in addition to and outside of regular club training twice a week. For skilled players specifically, the increase in training should be planned earlier than 16 years of age. The data clearly illustrate that significant differences emerge only after 13 years of practice. In comparison to the findings in wrestling, this is rather late.

From the analyses in Part II, specific ball games and exercises were clearly seen as very relevant, just as running and sleeping were. What may seem surprising, however, was that weight training and stretching were not rated highly.

STUDY 2: FIELD HOCKEY

Method

Participants

Three groups of male field hockey players voluntarily participated in the study. They were all players in Belgian field hockey leagues. The international players (n = 16) were all in the first division and played for the national team. Most were selected for the World Cup 1994 in Australia, for the European Cup 1995 in the United Kingdom, and for the pre-Olympic tournament 1996 in Spain. The national players (n = 18) also played in the first division. Most were selected on a

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regular basis for the national youth teams. The provincial players (n = 17) performed in the fourth division. The current ages of the three groups were as follows: international, 25.9 years; national, 24.4 years; and provincial, 25.2 years.

Procedure

The same basic procedure, questionnaire, and data analyses were employed as in the first study but adapted for field hockey (in Bonferroni's tests, alpha was divided by 27, the number of activities).

Reliability

In order to increase reliability estimates of the career retrospective reports, an additional method (proposed by Pedhazur & Schmelkin, 1991) was used. For each of the activities discussed, participants indicated how sure they were about the information provided by putting a landmark on a 10-cm line that went from *very unsure* to *very sure*. These data were then analyzed using a 3 skill (international, national, provincial) × 3 activities (individual and team practice, hockey-related activities, everyday activities) mixed ANOVA.

Results: Part I

Biographic Information

All groups began playing hockey at a similar age (M = 8.6 years ± 0.6) and also engaged in team practice at the same time (M = 8.7 years ± 0.6). Both the international (M = 19.1 hr ± 5.1) and national (M = 12.9 hr ± 6.9) players reached their peak in individual plus team practice relatively late, at 18 and 12 years into career respectively. International players were then 27 years of age and the national players 21. The fact that national players peaked much earlier is the result of a new national training regime implemented a few years ago. This meant that younger, promising players who aspired to national teams were provided additional training opportunities beyond regular club play. Provincial players reached their peak at 9 years (M = 8.1 hr ± 5.4) into career (18 years of age).

Retrospective Estimates Over the Field Hockey Players' Careers

Individual Practice. The analyses of individual practice data showed a significant main effect of years into career ($F(2, 288) = 8.98$, $p < .0001$), as well as a significant skill × years into career interaction ($F(12, 288) = 3.75$, $p < .0001$). The main effect of skill was not significant. The interaction and subsequent post hoc tests are shown in Figure 3.

Across skill level, at 18 years into career there was a significant difference between international (M = 8.6 hr/week) and both national (M = 3.5 hr/week) and provincial players (M = 3.5 hr/week). Across years into career, there were no significant differences in individual practice for national and provincial players. For the international players, however, individual practice significantly increased from 3 (M = 4.25 hr/week) to 18 years into career (M = 8.6 hr/week).

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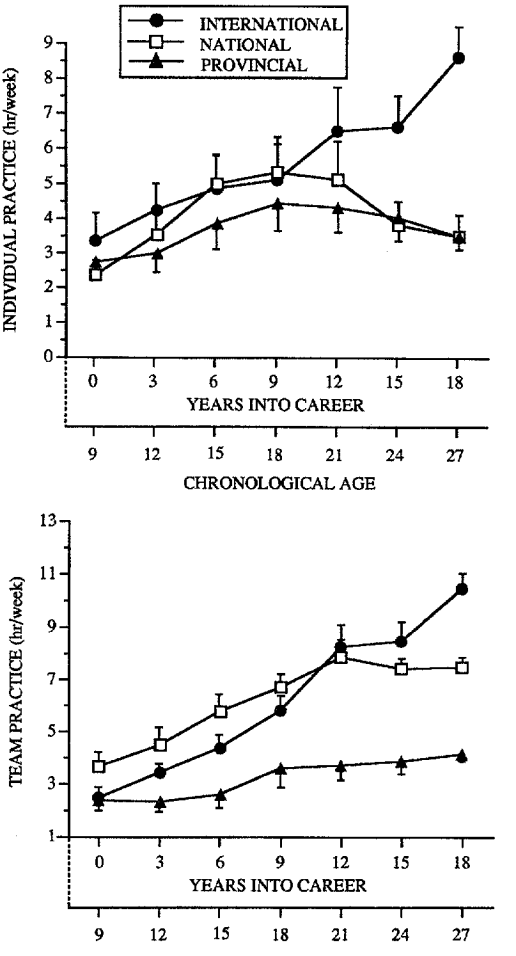

Figure 3—Mean hours per week (and standard errors) spent in individual practice and team practice as a function of the number of years into field hockey career and chronological age.

Team Practice. The analyses of team practice data showed that both main effects of skill ($F(2, 48) = 16.76$, $p < .0001$) and years into career ($F(6, 288) = 63.43$, $p < .0001$) were significant. The skill × years into career interaction also was significant ($F(12, 288) = 9.48$, $p < .0001$). This interaction and subsequent post hoc tests are highlighted in Figure 3.

Across skill level, there was a significant difference between national and provincial players at 6 (national, $M = 5.8$ hr/week; provincial, $M = 2.6$ hr/week) and 9 years into career (national, $M = 6.7$ hr/week; provincial, $M = 3.6$ hr/week). The differences between both the international and the national players on the one hand, and the provincial players on the other, were significant at 12 (international, $M = 8.2$ hr/week; national, $M = 7.9$ hr/week; provincial, $M = 3.7$ hr/week) and 15

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years into career (international, $M = 8.5$ hr/week; national, $M = 7.4$ hr/week; provincial, $M = 3.8$ hr/week). Overall significant differences between each and every skill level were shown at 18 years into career (international, $M = 10.5$ hr/week; national, $M = 7.5$ hr/week; provincial, $M = 4.2$ hr/week). Across years into career, there was no significant increase in team practice for the provincial players from the start ($M = 2.4$ hr/week) up to 18 ($M = 4.2$ hr/week) years into career. For both international and national players, team practice significantly increased from the start (international, $M = 2.5$ hr/week; national, $M = 3.6$ hr/week) up to 9 years into career (international, $M = 5.8$ hr/week; national, $M = 6.7$ hr/week). Past 9 years into career, however, international players continued to significantly increase team practice up to 18 years into career, while national players did not (international, $M = 10.5$ hr/week; national, $M = 7.5$ hr/week).

Accumulated Practice. The analyses of accumulated practice data showed that both main effects of skill ($F(2, 48) = 3.67$, $p < .05$) and years into career ($F(18, 864) = 247.42$, $p < .0001$) were significant. The skill × years into career interaction also was significant ($F(36, 864) = 5.60$, $p < .0001$). This interaction and subsequent post hoc tests are highlighted in Figure 4.

Across skill level, there was a significant and consistent difference between international players and provincial players from 16 years into career on (international, $M = 8541$ hr; provincial, $M = 5341$ hr). At 18 years into career, the difference between national and provincial players was also significant. By then, accumulated practice hours were 10,237 for international players, 9,147 for national, and 6,048 for provincial.

Another way of conceptualizing the data on accumulated practice is to examine what percentage of total accumulated hours is constituted by team vs. individual practice. Table 3 reports accumulated practice in both sports and for

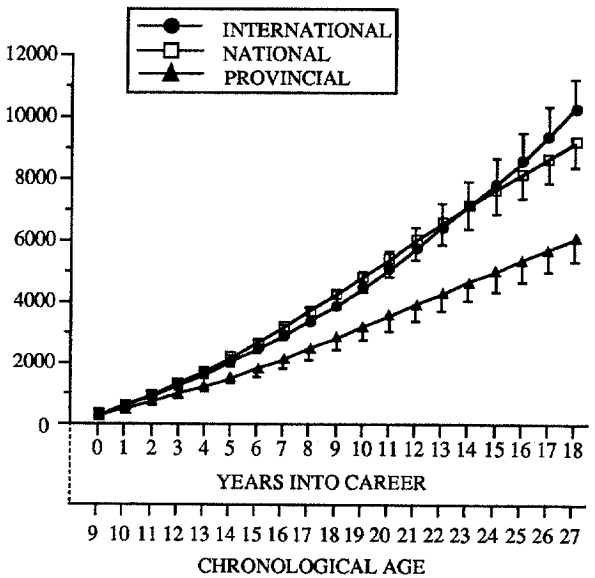

Figure 4—Accumulated practice hours (and standard errors) as a function of the number of years into field hockey career and chronological age.

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each skill level at 18 years into career. Accumulated practice is further broken down into the contributions arising from individual and team practice.

Team practice routinely accounts for approximately 64% of accumulated practice in soccer, yet only 53% in field hockey. There is also a tendency for total accumulated practice to be more evenly distributed between team and individual practice at the provincial level as opposed to the higher skill levels.

Reliability

The Pedhazur and Schmelkin (1991) style analysis of reliability showed that the main effect of activity was significant ($F(2, 30) = 9.30$, $p < .001$), whereas the effect of skill and the overall activity × skill interaction effect were not. Post hoc tests demonstrated that both the information provided on individual and team practice ($M = 6.7 \pm 1.8$) and on hockey-related activities ($M = 6.7 \pm 1.8$) were rated significantly higher than the estimates on everyday activities ($M = 5.7 \pm 1.9$).

Results: Part II

Evaluations for Field Hockey–Related and Everyday Activities

Table 4 is a summary of the evaluations for the various activities related to individual and team practice, field hockey–related and everyday activities averaged across groups. Once again, data were remarkably similar across skill groups and within the relevance, effort, enjoyment, and concentration dimensions; thus data were collapsed across groups. As before, an *H* denotes a mean higher than average and an *L* denotes a mean lower than average.

Individual Practice. Training alone with the coach, technical skills, and

Table 3 Total Accumulated Practice Hours and Total Accumulated Hours for Individual vs. Team Practice

		Soccer			Field Hockey		
		Team	Individual	Total	Team	Individual	Total
International	*M*	6,083	3,250	9,332	5,375	4,863	10,237
	SE	223	315	417	404	685	980
	%	65	35	100	53	47	100
National	*M*	4,825	2,624	7,449	5,466	3,681	9,147
	SE	202	215	268	382	532	805
	%	65	35	100	60	40	100
Provincial	*M*	3,113	1,966	5,079	2,765	2,283	6,048
	SE	178	155	234	340	452	721
	%	61	39	100	46	54	100

Note. Data are for both soccer and field hockey players at 18 years into career. Means, standard error and percent contribution (%) are shown.

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Table 4 Evaluations for Various Activities Related to Individual Practice, Team Practice,Field Hockey-Related, and Everyday Life Across Groups

	Relevance	Effort	Enjoyment	Concentration
Individual practice				
Weights	6.05	6.28^{H}	4.41^{L}	4.00^{L}
Flexibility	6.82	4.98	4.36^{L}	4.59
Running	8.67^{H}	6.98^{H}	5.25	4.71
Game video analysis	6.50	2.60^{L}	7.05	5.41
Tennis	4.30^{L}	3.52	8.04^{H}	7.06^{H}
Coach alone	8.31^{H}	4.98	7.27	7.36^{H}
Technical skills	8.78^{H}	4.23	8.80^{H}	8.18^{H}
Team practice				
Games	8.82^{H}	5.37	9.25^{H}	8.98^{H}
Exhibition games	7.53^{H}	4.78	8.27^{H}	7.33^{H}
Tactical skills	8.24^{H}	5.36	7.04	8.00^{H}
Technical skills	8.31^{H}	5.20	7.88^{H}	7.76^{H}
Weights	5.68	6.05	4.33^{L}	3.86^{L}
Running	8.59^{H}	7.06^{H}	4.78^{L}	4.24^{L}
Flexibility	6.74	5.39	4.80^{L}	4.26^{L}
Swimming	3.38^{L}	5.08	4.85^{L}	3.08^{L}
Hockey-related				
Reading journals	2.58^{L}	2.55^{L}	5.83	3.29^{L}
Mental imagery	6.61	4.96^{L}	5.78	6.96
Watching hockey	7.16	2.00^{L}	7.56^{H}	4.68
Pro. conv. hockey	6.40	2.49	6.61	4.65^{L}
Coaching	6.04	5.16	7.04	7.65^{H}
Leading tr. sessions	5.53	5.65	6.91	7.51^{H}
Game-analysis	7.71^{H}	5.13	5.92	7.29^{H}
Everyday life				
Sleep	7.92^{H}	1.68^{L}	8.12^{H}	0.80^{L}
Study	3.72^{L}	7.20^{H}	2.68^{L}	8.32^{H}
Active leisure	5.45	4.24	8.67^{H}	5.37
Work	3.68^{L}	6.00	6.36	7.45^{H}
Nonactive leisure	3.33^{L}	2.35^{L}	7.37	3.28^{L}
Means	6.40	4.71	6.49	5.78

Note. 0 = low; 10 = high.

running were all given significantly high ratings for relevance. Running was also rated highly for effort, along with weight training, whereas training with the coach and technical skills received high ratings for concentration. Technical skills also received a high rating for enjoyment, whereas both weights and flexibility training were rated significantly low for enjoyment.

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Team Practice. Five out of the eight activities included under this heading were judged as highly relevant to improving performance in field hockey. These included regular games, exhibition games, tactical skills, technical skills, and running. Swimming was the only activity judged as significantly low in relevance. As with individual practice, running also received a high rating for effort, but was judged low for enjoyment and concentration. Weight training, flexibility training, and swimming also were rated low for enjoyment and concentration. This was in contrast to technical skills and exhibition games, which both received significantly high rankings for these dimensions.

Field Hockey–Related. Game analysis was the only activity to be rated higher than the overall mean for relevance as well as concentration, whereas reading field hockey journals was rated significantly low for relevance. Watching field hockey was judged a highly enjoyable activity, but was rated low for effort, along with reading and mental imagery. Coaching, leading training sessions, and game analysis were all rated significantly higher than the overall mean for concentration.

Everyday Life. Sleep was the only activity that received a high rating for relevance, and as expected, it was also judged as a highly enjoyable activity, effortless and not requiring concentration. Study, work, and nonactive leisure were all rated low in relevance to improving performance, and study and work received high rankings for concentration.

Discussion

In this study, field hockey players began practicing at 9 years of age, which is similar to the 8 years of age noted for musicians (Ericsson et al., 1993). Both for the international and national players, the difference between the starting ages and current peaks in individual plus team practice averaged 18 years and 12 years respectively.

The retrospective estimates demonstrated that practice did differentiate between hockey players of different skill levels. In accordance with previous literature (Ericsson et al., 1993), international players spent more time in individual practice across their career when compared to national and provincial players. Contrary to Ericsson et al.'s definition of deliberate practice, both the international and national players spent more time in team practice compared to provincial players at 12 and 15 years into career. In addition, there were significant differences between each skill level at 18 years into career (international, $M = 10.5$ hr/week; national, $M = 7.5$ hr/week; provincial, $M = 4.2$ hr/week). According to these findings, it is absolutely necessary to include both individual and team practice data as components of deliberate practice when calculating accumulated practice. Finally, accumulated practice estimates at 13 years into career for the international and national hockey players yielded similar results as those at 10 years into career for Ericsson et al.'s (1993) best violinists and Hodges and Starkes' (1996) most skillful wrestlers (international field hockey players $M = 6403$ hr, national field hockey players $M = 6559$ hr, violinists $M = 6351$ hr, wrestlers $M = 5865$ hr). As was also done with soccer, off-season time was taken into account when yearly amounts of practice were estimated. Since length of the off season was not considered in Ericsson et al. (1993) the estimates of accumulated practice in this paper are relatively more conservative.

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From the field hockey study it can be seen that the activities rated as highly relevant were also rated high for concentration, with the exception of running, which was judged to be highly effortful.

GENERAL DISCUSSION

Once again the 10-year rule has held. These studies of soccer and field hockey suggest that around 10 years into career, important decisions and choices are made with regard to the course of one's athletic career. In the case of soccer, around 9 years into career the international players commit to much more intensive team training and begin to decrease time spent on individual practice. In terms of team practice, the absolute amounts increase very steeply from 9 to 15 years into career and then seem to level off. In field hockey, around 9 years into career both national- and international-level players show steep increases in the amount of time spent in team practice. International players continue to increase time spent in individual practice from 9 right through 18 years of their career. In contrast, national- and provincial-level players (like soccer players) begin to decrease the amount of time they spend working on individual skills after 9 years. An important aspect of these studies is that they go beyond our general knowledge that expertise requires 10 years to develop and for the first time suggest the kinds of practice athletes engage in at 10 years and beyond. In Scanlan's terms (Carpenter et al., 1993; Scanlan et al., 1993a, 1993b) 9 years appears to be a watershed period, after which significantly more personal investment of time and effort must be committed if one is likely to reach international or national skill level. The sport commitment model would predict that athletes at this time period would also have increased personal commitment to the sport.

A second important finding of these studies was that retrospective recall of the current year's practice activities can be verified reliable by the 1-week diaries. In addition, high test-retest reliabilities were found for retrospective reports collected at 6-month intervals. It was also found that international athletes have the highest reliability estimates of recall. This is probably because either practice has played such an important role in their lives that it is readily recalled, or because practice consumes such a great deal of their life that everything else must be scheduled around it. This leads to a very routine schedule and, as a result, practice times are readily recalled. Finally, from the Pedhazur and Schmelkin (1991) style confidence analysis it was shown that athletes do have confidence in their abilities to recall practice activities, more so than their other sport-related or everyday activities.

The third important finding of these studies was the monotonic relationship demonstrated once again between amount of deliberate practice (in these cases both individual and team) and eventual performance level attained. These data corroborate the original findings of Ericsson et al. (1993), and others (Hodges & Starkes, 1996; Starkes et al., 1996). Caution is warranted, however, because such findings would be difficult to refute unless situations are found where either increases in practice do not lead to improved performance, or high performance levels are attained in spite of very little practice. Nevertheless, one remarkable aspect of the finding is that regardless of the age at which an activity is begun, the monotonic relationship with skill is quite consistent. Even across domains, the absolute amount of practice accumulated over time is remarkably similar at different career stages.

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If the theory of deliberate practice is to be applied in any meaningful way to the domain of sport, it is clear that the definition of deliberate practice must be expanded to include both individual practice and either practice with others (as in the case of wrestling) or team practice in sports like soccer and field hockey. This would mean either adapting the theory in general to include these forms of practice, or assuming that what constitutes deliberate practice may in fact be different across domains. If the actual definition of deliberate practice is specific to each and every domain, one must question the relevance of the theory as a general theory of expertise.

It is particularly interesting to note that those activities judged most relevant were also judged to be most enjoyable. These findings replicated the results of Hodges and Starkes (1996), whose wrestlers also reported relevant practice activities as enjoyable. This contrasts with the definition of deliberate practice originally proposed by Ericsson et al. (1993). Recall that deliberate practice was not seen as inherently enjoyable, although the improved results of practice were. Hodges and Starkes (1996), however, pointed out that even within Ericsson et al.'s original data, the ratings for practice alone and with others were actually higher than the overall mean. As with wrestling, team sports like soccer and field hockey are inherently social activities, and both competitive and physical in nature, all of which athletes find enjoyable. Ericsson's (1996) explanation of this discrepancy with enjoyment is that practice in sports is inherently social and it is this social aspect that individuals find enjoyable, as opposed to practice itself. Were this the case, it would be difficult to explain why field hockey players working totally alone on technical ball-handling skills continue to rate this activity as highly enjoyable.

Another interesting finding was the importance of concentration as a separate dimension from effort. This is an important distinction when referring to more obvious physical activities. It would appear that concentration refers more to the cognitive effort required in an activity, whereas effort refers to the physical effort of the activity. For example, mental rehearsal and working alone with the coach were rated high for both relevance and concentration, whereas running and weight training were rated significantly higher than the overall mean for effort. This distinction is especially important in light of the finding that relevance correlates most highly with concentration. In music this distinction may be less acute because practice involves less physical effort.

With regard to support for a theory of expertise based solely on deliberate practice the answer is still unclear. Because these studies were cross-sectional, the international players were already experts; conclusions therefore cannot be made about the causative nature of practice. Indeed, it may be that those who are more "talented" are more motivated and consequently practice more. Much of the data would suggest that the most critical part of producing skilled athletes is to find individuals who are highly motivated and likely to persist over the long duration required to produce an expert.

The model of sport commitment (Carpenter et al., 1993; Scanlan et al., 1993a, 1993b) suggests the factors that would lead to such persistence. Recall that enjoyment is a key factor in young athletes' commitment. These studies have demonstrated that many practice components are highly enjoyable for athletes. This follows Scanlan's model but not Ericsson's. Likewise, the increasing amounts of deliberate practice required would suggest that as athletes improve and devote more time to practice, their personal investment of time increases, and the effort put into

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highly relevant practice activities increases, so there is increased commitment and persistence by the athlete. The sport commitment model provides an outline of the motivational structure and precursors necessary for the development of expert performance. It may be that skill improvement, or increased competence, may also be a significant motivator. This is likely to be more powerful early in practice, when the largest performance gains are obvious. Early gains help justify the personal investments of time and effort and certainly increase enjoyment.

At this point several questions remain. One concerns the true nature of practice vs. estimates made by athletes. For example, even though athletes rate certain activities as highly relevant to improving performance, we do not know to what extent these activities are the ones actually pursued in practice. A time-motion study of the microstructure of practice would begin to address this, and this is the current direction of research.

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Notes

[1]Ericsson has used sport examples in his presentations at several conferences, including: The Max Planck conference on expertise, Berlin (1989); North American Society for Psychology of Sport and Physical Activity (NASPSPA), Clearwater, FL (1994); American Educational Research Association (AERA), San Francisco (1995); and the Conference on the acquisition of expertise, Wakulla Springs, FL (1995).

[2]Ericsson's publications routinely discuss the structure of practice in the daily lives of elite performers. His discussion of the role of practice for elite athletes is often an integral part of these articles, although he does not pursue sport research himself (Ericsson, 1996; Ericsson & Charness, 1994; Ericsson et al., 1993; Lehmann & Ericsson, 1996).

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