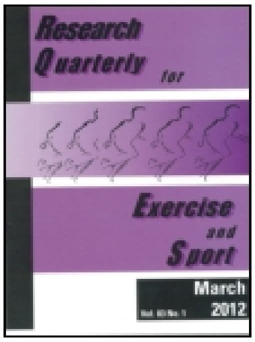

Research Quarterly for Exercise and Sport

ISSN: 0270-1367 (Print) 2168-3824 (Online) Journal homepage: http://www.tandfonline.com/loi/urqe20

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Research Quarterly for Exercise and Sport
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Physical Education, Recreation and Dance
Vol. 74, No. 3, pp. 342–347

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Key words: expertise, decision making

Studies examining the component skills of expert performers have revealed that experts in team ball sports differ from other players in a range of attributes. Experts are characterized by superior perceptual skills, especially in terms of pattern recognition and anticipation (e.g., Abernethy, 1990), superior decision-making skills, especially in terms of knowledge of appropriate tactics and procedures (e.g., McPherson, 1994), and superior movement execution skills, especially in terms of movement adaptability and automaticity (e.g., Parker, 1981). Better athletes in these sports are also characterized by high levels of physiological preparedness (physical fitness) for the specific demands of their sport (e.g., Crouse, Rohack, & Jacobsen, 1992).

Studies examining expert performance in the context of practice histories have revealed that across a range of domains, including sport, a minimum of 10 years of sustained practice appears to be a necessary condition for developing expertise (e.g., Simon & Chase, 1973). Indeed, an emerging view, championed most strongly by Ericsson, Krampe, and Tesch-Römer (1993), is that there is a monotonic relationship between the number of hours of deliberate practice undertaken and the performance level achieved. Deliberate practice is considered in this context to be done with the specific goal of improving performance, is effortful and attention-demanding, is not necessarily enjoyable, and does not lead to immediate social or financial rewards (Ericsson et al., 1993). A more moderate position (e.g., see Singer & Janelle, 1999) is that, while the sheer quantum of practice is important, other factors, such as genetics in addition to the type and quality of practice, are also likely to be (equally?) critical conditions for attaining expertise. Despite a relatively long history of laboratory-based studies of motor learning (e.g., for a review, see Schmidt & Lee, 1999), surprisingly little is yet known about what types of practice best facilitate acquiring the component skills in perception, decision-making, movement execution, and physical fitness that characterize expert performance in team ball sports.

Examining the practice histories of expert performers has the potential to provide a valuable source of information about the types of practice that may facilitate development of the component skills needed for expert performance (Helsen, Starkes, & Hodges, 1998). Recent studies in individual sports and artistic domains have demonstrated how information obtained from the practice histories of experts may be used in this way. For example, mat work and coach instruction have been shown to be most relevant for developing wrestling expertise (Hodges & Starkes, 1996), on-ice training and coaching instruction are most relevant for figure skaters (Starkes, Deakin, Allard, Hodges, & Hayes, 1996), organized classes and kata training are most relevant for martial artists (Hodge & Deakin, 1998), and solo practice and private lessons are most relevant for musicians (Ericsson et al., 1993). The purposes of this study were: (a) to examine the role of different forms of training in developing component skills known to characterize expert performance in team decision-making sports, and (b) to investigate differences between the type and

Submitted: March 5, 2001
Accepted: August 4, 2002

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quantity of training undertaken by experts and nonexperts in these sports.

Method

Participants

The current investigation is part of a larger study examining expert decision making in sport (Abernethy, Côté, & Baker, 2002; Baker, Côté, & Abernethy, 2003). The expert group consisted of 15 current Australian national team athletes(3 female netball players, 4 male field hockey players, 4 female field hockey players, and 4 male basketball players). These players were nominated by their national team coaches as being among the best decision makers in their sports worldwide. At the time of data collection, each team from which the participants were drawn was highly ranked internationally. The women's netball and field hockey teams were world champions, while the men's field hockey and basketball teams were ranked second and fourth in the world, respectively. The experts sampled had a mean age of 27.6 years ($SD = 4.3$) and had been playing their sport for an average of 20.7 years ($SD = 5.3$).

The control group of 13 nonexperts consisted of individuals with more than 10 years of experience in their sport but with maximal participation level no higher than state representation and were drawn from men's basketball ($n = 4$), women's netball ($n = 3$), men's field hockey ($n = 3$), and women's field hockey ($n = 3$). The average age for this nonexpert group was 23.2 years ($SD = 4.6$), and the players in this group had been involved in their sport for an average of 12.2 years ($SD = 1.7$). All participants in the expert and nonexpert groups provided informed consent prior to the beginning of data collection.

Data Collection Procedures

All participants completed a structured interview based on that developed for gymnasts (Beamer, Côté, & Ericsson, 1999), designed to elicit information regarding practice activities undertaken throughout the duration of their careers. The interview lasted 2–3 hr, during which time athletes provided detailed information on a number of aspects of their practice histories.

For each year of their sport involvement, participants were first asked to list all activities related to the sport in which they participated. This included activities undertaken in the off-season as well as in the competitive season. Athletes were then asked to consider the following activity categories to ensure that a comprehensive list of activities was generated: (a) indirect involvement (e.g., watching games on television or live), (b) organized games with rules supervised by self and peers, (c) organized games supervised by coach(es) or adult(s), (d) organized training in group supervised by coach(es) or adult(s), (e) individualized instruction, (f) self-initiated training (e.g., skill training alone that is initiated by the athlete), and (g) organized competition in groups supervised by adult(s).

After developing a complete list of training activities for each year of involvement, athletes then provided details on the number of hours per week and months per year of involvement for each activity. From this information, cumulated training hours for each activity were estimated. In addition, each athlete rated each of the specific training activities on a scale from 0 (no help) to 3 (very helpful) with respect to perceived helpfulness in developing essential component skills in perception, decision making, movement execution, and physical fitness. For clarity, each component skill was succinctly defined for the participants: perception, as the ability to "read the play;" decision making, as choosing the correct movement option; movement execution, as organizing and performing the movement; and physical fitness, as the conditioning necessary to play effectively.

Reliability and Validation

The interview task relied extensively on the athletes' retrospective recall. Data derived in this form can be problematic due to the difficulty associated with remembering experiences from a period in the extended past. However, some researchers (e.g., Helsen et al., 1998) argued that sport experts have facilitated recall due to the relative importance of training in their daily routine. For expert athletes, training is a primary focus of their lives, and, therefore, they might be expected to recall details about training with considerable accuracy. Nonetheless, due to the complexity and depth of information the athletes were required to recall, a number of steps were taken to cross-validate the collected data.

To validate the number of reported training activities for the expert athletes, the number of training activities reported for the current year was compared among athletes who were part of the same team (male and female field hockey players, $n = 8$). The distribution of scores around the mean value (men's field hockey $M = 6.4$, $SD = 0.6$; women's field hockey $M = 6.4$, $SD = 0.5$) indicated a good degree of agreement between the athletes.

To validate the number of training hours reported by the expert participants, a sample ($N=10$) of the parents most knowledgeable about each individual expert athlete's sporting career was interviewed. The Pearson product moment correlation between the parents' reported data regarding total training hours per year and the data provided by the expert athletes was $r = .59$ ($p <$

.05), indicating a reasonable level of concordance considering the time over which recall was required. Because of their various geographical locations and inaccessibility, validation interviews with nonexperts' parents were not conducted. However, a redundant item built into the interview protocol indicated a high degree of reliability for training hours data reported by expert and nonexpert athletes ($r = .73$; $p < .05$). Moreover, evidence from the exercise literature indicates that reported lifetime activity has high test-retest reliability (correlations in the 0 .7 range; Friedenreich, Courneya, & Bryant, 1998). This evidence, along with that collected from the experts' parents, provides reasonable confidence that nonexperts, like experts, should be able to estimate reliably the number of hours they spent training at different periods in their development.

Table 1. Number of athletes participating in various training activities

Activities	Experts (n = 15)	Nonexperts (n = 13)
Competition	15	13
Organized training	15	13
Video training	12	0
Individual instruction with coach	15	2
Watching games on television	8	4
Watching games live	13	10
Playing with friends	10	7
Practice alone	12	7
Reading about sport	5	3
Weight training	15	5
Aerobic training	11	9

Results

Training Activities

Table 1 lists the various training activities reported by the expert and nonexpert athletes. Expert athletes generated 11 common training activities: competition (all organized games), organized training (e.g., team practices), individual instruction with coach, practice alone (e.g., shooting practice), aerobic training (e.g., running, cycling), weight training, playing with friends (e.g., pick-up games, unorganized involvement), watching games on television, watching games live, reading about sport, and video training. Nonexpert athletes generated a similar list. However, nonexperts did not participate in video training, and only two nonexperts received individual instruction (and only for 1 year).

Helpfulness of Training Activities

The ratings of helpfulness of different training activities were compared between experts and nonexperts using independent t tests with a Bonferroni adjustment applied to correct for possible experimentwise error. No significant differences between experts and nonexperts were found ($p < .05/44 = .001$) for any of the activities. The ratings data for both skill groups were, therefore, combined, and descriptive statistics for the whole sample calculated (see Table 2).

To identify activities on the extremes of helpfulness (i.e., least and most helpful activities) the mean rating of each activity was classified into three different categories: (a) not helpful (mean rating between 0 and .99), (b) somewhat helpful (mean rating between 1 and 1.99), and (c) helpful (mean rating between 2 and 3).

Table 2. Athletes' ratings of perceived helpfulness of training activities for developing component skills for expert performance

Activity	Perception		Decision making		Execution		Physical fitness	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Competition	2.5	0.5	2.6	0.7	2.5	0.6	2.4	0.6
Organized training	2.0	0.7	2.2	0.7	2.6	0.4	2.2	0.5
Video training	2.2	0.5	2.2	0.6	1.5	0.8	0.2	0.4
Individual instruction with coach	1.4	1.0	1.6	0.8	2.8	0.3	1.5	0.7
Watching games on television	2.0	0.7	1.9	0.8	1.2	1.0	0.2	0.6
Watching games live	1.9	0.8	1.7	0.9	1.3	1.0	0.1	0.4
Playing with friends	1.2	1.1	1.2	1.0	2.1	0.9	1.2	1.0
Practice alone	0.5	0.6	0.8	0.8	2.6	0.5	1.1	0.8
Reading about sport	1.1	1.1	0.9	0.8	0.7	0.9	0.1	0.3
Weight training	0.0		0.0		0.8	1.1	2.1	0.9
Aerobic training	0.1	0.3	0.1	0.4	0.6	1.1	2.5	0.6

Note. M = mean; *SD* = standard deviation.

Because the "somewhat helpful" category does not present a clear picture of the helpfulness of each activity, only activities deemed not helpful (a mean rating < 1) and activities deemed helpful (mean rating > 2) will be discussed further. The activities considered as helpful for developing perceptual skills were competition, video training, organized training, and watching games on television, while weight training, aerobic training, and practice alone were considered not helpful. Activities rated as helpful for developing decision-making abilities were competition, video training, and organized training, while weight training, aerobic training, reading about sport, and practice alone were rated as not helpful. Individual instruction with the coach, practice alone, organized training, competition, and playing with friends were considered helpful for movement execution. Aerobic training, reading about their sport, and weight training were rated as not helpful for developing movement execution. The activities rated as being helpful for developing physical fitness were aerobic training, competition, organized training, and weight training, while reading about their sport, watching games live and on television, and video training were rated as not helpful in this area.

Time Spent in Training Activities

The cumulative hours spent in training activities were examined to determine any differences between experts and nonexperts (see Table 3). Due to a marked drop in nonexpert participants after the age of 20 years, total hours spent in practice were only calculated and compared across skill groups up to this age. One glaring difference in time use on activities between the experts and nonexperts was in the use of video-based training. Whereas experts had spent an average of 194.5 hr in video training by the age of 20 years, no nonexperts had participated in this type of practice. To test for differences between experts and nonexperts, *t* tests with a Bonferroni adjustment applied ($p < .05/11 = .0045$) were conducted for each training activity, with the exception of video training. Table 3 shows the mean number of hours spent in each activity for the experts and nonexperts, *t* test values, and effect sizes. Large significant differences were found for competition, organized training, and individual instruction with coach.

Discussion

One focus of the present study was to identify training activities that were helpful to developing abilities necessary for success in team ball sports. To this end, both expert and nonexpert players perceived competition, video training, organized training, and watching games on television as helpful activities for developing the perceptual skills necessary for expert performance in team sports, while they reported competition, video training, and organized training as helpful for developing decision-making skills. Athletes considered individual instruction with the coach, practice alone, organized training, and playing with friends to be helpful activities for developing movement execution skills, while they regarded aerobic training, competition, organized training, and weight training as helpful for developing physical fitness. Expert and nonexpert decision makers were essentially identical in their ratings

Table 3. Comparison of mean accumulated hours spent in training activities by expert and nonexpert players

Activity	Expert	Nonexpert	*t*	Effect size (*d*)
Competition	1,288.4	463.9	13.1*	1.31
Organized training	2,561.1	882.7	6.9*	1.14
Video training	194.5	0.0	nd	nd
Individual instruction with coach	291.1	34.3	9.5*	0.99
Watching games on television[a]	618.5	1,270.5	0.9	0.57
Watching games live	1,154.1	327.6	2.7	1.01
Playing with friends	1,145.6	1,855.7	1.1	0.54
Practice alone[a]	931.3	767.7	0.3	0.15
Reading about sport	581.2	200.0	1.0	0.73
Weight training[a]	426.0	752.0	1.4	0.89
Aerobic training[a]	481.3	731.0	1.2	0.43

Note. nd = no data reported for nonexpert players.
[a]Levene's test indicated an inequality of variance for these training activities.
*$p < .0045$ (Bonferroni correction = 0.05 / 11).

of the respective use of the different training and practice activities in which they had participated. It may well be prudent for coaches and athletes interested in improving overall skill performance in team sports to ensure that these activities form an integral part of players' developmental experiences.

While experts and nonexperts reported participating in essentially the same types of training, analysis of the hours spent undertaking the activities considered helpful to skill development also revealed some important information. Previous research (e.g., Helsen et al., 1998; Starkes et al., 1996) indicated that experts perform more training hours than nonexperts. The current study extends these findings by demonstrating that not only do experts spend more time overall in practice but they also devote more time to participating in certain specific activities (i.e., video training, organized team practice, individual instruction with the coach, and competition) that they, and nonexperts, deem the most helpful to developing the essential component skills for expert performance. The experts in this study reported spending considerable time on video training, whereas the nonexperts did not report this activity. This observation is interesting, given the growing evidence that video-based training may be beneficial to develop sport-specific perceptual and decision-making skills (Abernethy, Wood, & Parks, 1999).

The results of the current study are generally consistent with the contention of Ericsson et al. (1993) that deliberate practice is the most effective form of training for developing expert performance. Practice alone, individual coach instruction, organized training, video training, and aerobic training are all helpful, structured activities that require large amounts of cognitive and physical effort and certainly satisfy most, if not all, the criteria for deliberate practice activities (the possible exception being the issue of inherent enjoyment in sport participation; cf. Ericsson, 1996; Helsen et al., 1998). One important point of contention concerns the athletes' ratings of the helpfulness of competition to skill development. The benefits of participation in competition have not been considered in the deliberate practice studies performed to date, yet in the current study competition (i.e., match play) was rated as the most helpful form of training for developing perceptual and decision-making skills and was rated highly for developing skill execution and physical fitness. This oversight in the research to date probably arises, because competition per se is not included with the definition of a deliberate practice activity as originally presented by Ericsson et al. (1993). While competition requires high amounts of cognitive and physical effort, it is not strictly designed with either the singular or principal purpose of improving specific performance components. Further revision of the deliberate practice view of expertise may be necessary in light of the important role both experts and nonexperts ascribe to competition in developing the component skills characteristic of expert performance, at least in team ball sports.

The current observations on the importance of different types of practice are clearly preliminary, and future research needs to build on this work, while correcting for possible limitations of the current methodology. For instance, increasing the sample size may facilitate the identification of further differences between experts and nonexperts not evident in this modest sample. Similarly, identifying expert and nonexpert athletes from the same age group with similar years of training experience, although difficult, would prevent the possibility of any experience-related biases in subsequent analyses. A limitation of the present study is that information from nonexperts was not validated. Although it is difficult, researchers should strive to validate information from nonexpert or novice comparative groups to ensure that bona fide comparisons are being made. Our understanding of the training factors associated with the development of expert performance is far from complete. In particular, supplementary research on the role specific training activities play in developing requisite skills is clearly required.

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Authors' Notes

During the completion of this research, the first author was with the School of Human Movement Studies at The University of Queensland, and the second author was on research leave at the School of Human Movement Studies, The University of Queensland. The authors would like to extend appreciation to Deborah Hoare, Ross Smith, and the coaches and athletes of the Australian National Men's Basketball, Women's Netball, and Men's and Women's Field Hockey teams for their support and patience during completion of this study. The authors would also like to extend appreciation to Stephen Cobley, Andrew Wright, and Madelyn Beamer for helpful comments on an earlier version of this manuscript. This research was funded by the Australian Sports Commission and a standard research grant from the Social Sciences and Humanities Research Council of Canada (SSHRC # 410-99-0525). Please send all correspondence concerning this article to Joseph Baker, School of Physical and Health Education, Queens University, Kingston, ON.

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