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Microstructure of practice activities for team and individual sports

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ABSTRACT
Purpose. Research on the microstructure of practice activities has reported equivocal findings. Limited sports have been included in systematic observations. Playing form activities have not been examined for individual sports. This study scrutinized the amount of time devoted to different activities during practice and refined the usability of playing form and training form for various sports.
Methods. Systematic observations were conducted in an elite sports school. Youth athletes aged 16–20 years and coaches from 6 different sports (hurdling, archery, field hockey, netball, squash, volleyball) were involved. Practice activities were categorized as playing form, training form, and transition, and compared between sports.
Results. The proportion of different activities conducted during practice varied for each sport and coach. Hurdlers employed the longest time on transition (43%), squash players utilized the majority of time on playing form (40%), whilst the archers and all 3 team sports athletes consumed most time on training form (51–83%). Representatives of 3 sports did not engage in any playing form activities.
Conclusions. This study showed that elite coaches are still applying traditional approaches in structuring practice activities. Coaches should employ playing form during practice sessions, but the definition needs to be adapted to encompass multiple sports.
Key words: coaching, skill practice, sports school, systematic observation

Introduction

The bulk of an athlete's career is associated with coach-led practice activities [1–2]. However, little attention has been given to what athletes do during their practice sessions [3–5]. Athlete development models (e.g., Developmental Model of Sport Participation, Long-Term Athlete Development) proposed that engaging in purposeful practice activities was essential for attaining elite performance. Nevertheless, these models did not delineate what activities were required and in what amount. Researchers have recommended the need to examine the microstructure of practice sessions to determine which activities contribute to the development of expertise [4–7].

Practice activities that most closely resemble the competition have been proposed to be the most advantageous to improve performance in sports as they directly prepare athletes for competition; examples include a series of ice jumps for ice skating or getting a point at the last attempt to score [5, 8, 9]. Studies observing team sports have classified competition-like activities within a category termed 'playing form' (PF) and non-competition-like activities as 'training form' (TF) [10–12].

Block practice, commonly used as a traditional coaching method for closed skills [13], is considered as TF activity. In contrast, random practice, which replicates actual competition environment in open skills, is characterized as PF activity. PF refers to match-like practice activities, involving games or tactical aspects, while TF denotes drill-like practice activities, involving physical or technical aspects. Some studies added a 'transition/other' category, for activities that were neither PF nor TF (e.g., water break) [11, 12, 14, 15].

Initial studies examining detailed practice activities were conducted among youth football athletes. The first study to utilize the PF and TF categorization

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involved 25 football coaches for elite, sub-elite, and recreational players in under 9, under 13, and under 16 teams, and revealed that 65% of the time spent on practice was devoted to TF and 35% to PF [10]. Another study provided corresponding findings with reference to professional football coaches for under 10 and under 16 players, albeit with a smaller gap between TF (53%) and PF (47%) [16]. Two newer football studies involving youth athletes demonstrated that most time was devoted to PF, followed by transition and TF [14, 15]. The professional coaches for under 9–under 18 athletes devoted more than half of the session time to PF (57%), followed by TF (21%) and others (22%) [15], whereas club level under 11–under 17 teams utilized less than half the time on PF (41%), followed by inactivity (37%) and TF (22%) [14]. Although all these studies involved football, they showed dissimilar proportions of time spent on different activities.

Other sports also presented various figures. A yearlong observation of a national rugby team revealed that more than half of the practice activities involved PF (59%), with the remainders utilizing TF [17]. As the competition season approached, the proportion of PF increased up to 84%. Conversely, youth cricket club players employed TF in the bulk of practice time (69%), PF in a small portion (19%), and transition in the remaining time (12%) [12]. Moreover, observations of collegiate coaches from 3 team sports identified that about half of the practice time was devoted to training activities (41–45%), almost a quarter of the time to other activities (neither playing nor training, 16–24%), and the rest of the time to playing activities (35–39%) [11]. A comparison between activities showed that all 3 sports (hockey, volleyball, basketball) exhibited differences in time spent on other activities (neither playing nor training), which was significantly shorter than in the case of training activities. However, without a comparison between sports, it is not possible to identify the differences between sports that might further inform us on how practice sessions should be designed specifically for each sport.

Additionally, the amount of time spent on transition activity differed among skaters [8, 18]. National team skaters devoted the least amount of practice time to rest (14%) compared with provincial skaters (31%) and non-competitive skaters (46%) [8, 18]. It seemed as though transition activities played a substantial part during practice sessions (12–46% of practice duration) [8, 11, 12, 14, 15, 18].

A 3-part study comparing the microstructure of practice activities depending on age, skill level, and different sports showed mixed findings [7]. The first part compared 2 age groups (8–10- and 12–14-year-olds) in basketball and demonstrated that both groups utilized more practice time on play-like activities. The second part compared expertise level and identified that lower skilled youth football players devoted more practice time to play-like activities than to non-play-like activities, whereas higher skilled players spent almost similar amount of time on both types of activity. The third part compared disparate sports and implied that 11-year-old novice football players spent more time on play-like activities and less time on non-play-like activities, while a similar team of handball players did the contrary. Play-like activities are akin to PF whilst non-play-like ones are similar to TF. The studies which identified that more time was devoted to TF reasoned that the application of scientific findings that supported the use of PF in sports coaching was still lacking as coaches tended to rely on their previous experience, on what other coaches did, and on traditional methods to coach [10–12, 16].

PF and TF were based on skill acquisition and motor learning frameworks [10], but their implementation has not been tested beyond team sports. The existing definition of PF refers to games that may not be universally applicable to non-game sports and the exclusion of individual sports in recent studies confines the current scope of knowledge base. Not many sports have been involved in the systematic observation of the microstructure of practice activities [7, 8, 11, 12, 17, 19], with most research focusing on football [10, 14–16]. The majority of studies only included a single sport and employed sport-specific definitions that are not applicable to multiple sports [8, 10, 12, 14–17]. It is evident that various sports require different elements to excel [7, 11]. There is a need for research to encompass multiple sports in order to provide objective data for a meaningful comparison of the quality of practice across sports. It is unknown if previous findings regarding practice microstructure apply to all types of sports.

A number of studies described the type and amount of activities conducted during practice; however, some of them did so retrospectively or employed training diaries [20–22]. Retrospective information is usually based on regular schedules, it does not delve into the minutiae of each practice session. Researchers have identified that actual practice time may be overestimated in recalled information [8, 18]. Systematic observations and time use analysis enable researchers to scrutinize the activities conducted during practice sessions [19, 23, 24]. Additionally, not all studies that observed actual practice sessions reported transition activities, such as rest time [7, 10, 16, 17]. Without

data on transition activity, it is unclear whether it was excluded altogether. It is possible that a portion of the practice session was not identified.

This investigation endeavoured to systematically observe multiple sports within a single study, comprising PF, TF, and transition activity, to determine how and why the microstructure of practice activity differs between sports. To extend the present field of knowledge, this research examined both individual and team sports. Additionally, we attempted to inspect the usage of PF and TF in individual sports. The current research did not establish any dominant type of practice activity. Therefore, it was hypothesized that there would be no difference in the microstructure of practice activities between team and individual sports.

Material and methods

Participants

A Malaysian national sports school was selected with the method of purposive sampling. The sports school is an established institution that provides a specialized curriculum and sports training program to educate selected junior athletes in the country to become elite adult athletes in multiple sports. On the basis of convenience sampling, late adolescent athletes and their coaches from 6 sports (archery, hurdling, squash, hockey, netball, volleyball) at the institution were observed in this study. To enable group comparison, 3 team sports and 3 individual sports were selected. Three sports from each category were identified with the consideration of suitability, availability, and access allowed by the sports school, upon the coaches' agreement. While hurdling is an event, it was considered as an individual sport for this study. Participant information is presented in Tables 1a and 1b.

Procedure

Three practice sessions with the same coaches were recorded for each sport during the pre-competitive season. Three 90-minute sessions are required to represent the practice session for each coach [19, 23]. Other studies also observed 3 sessions per subject [8, 10]. Observations were conducted only in sport-specific locations (e.g., archery was observed in a shooting range). A video camera (Canon Legria FS200, Japan) was placed on a stationary, manoeuvrable tripod that provided a full view of the practice activities. The video recordings were then transferred to a computer and analysed by using performance analysis software (LongoMatch, version 1.3.2, Fluendo, Barcelona, Spain).

A total of 2294 minutes of practice activities were recorded. For each practice session, the total practice duration and amount of time devoted to different types

Table 1a. Athlete demographic and sports practice data

Sport	Age (years) (mean ± *SD*)	Gender	Competition level	No. of athletes	Training sessions per week	Training hours per week	Average duration of practice session (minutes)
Archery	19.5 ± 1.4	Mixed	National and international*	10	9	18	129
Hurdling	18.9 ± 1.8	Mixed		3	9	20	134
Squash	16.8 ± 0.2	Mixed		15	9	18	108
Hockey	17.1 ± 0.3	Male		14	9	18	112
Netball	17.9 ± 1.0	Female		16	9	22	149
Volleyball	18.0 ± 1.2	Male		9	9	16	132

* All athletes competed at the national level and 60% of the athletes competed at an international level.

Table 1b. Coach demographic and professional data

Sport	Age (years)	Gender	Years of coaching	Level of coaching	Coaching accreditation	Graduate
Archery	34	Female	9	National junior	Level 3 national*	Yes
Hurdling	50	Male	22			
Squash	32	Male	13			
Hockey	49	Male	25			
Netball	52	Female	31			
Volleyball	31	Male	11			

* Level 3 national is the highest accreditation within the country.

of activity were determined. All activities were measured on a session basis, as opposed to individuals. The start and end for each activity was timed when the first athlete commenced/ended that activity. During some practice sessions, different activities were conducted at the same time. For archery, some archers may have started warming up first from the moment they arrived, whereas the latecomers would be stretching when the earlier ones have started shooting. For field hockey, some players may be doing a drill on passing, whereas goalkeepers may be working on stopping shots at goal. In such cases, the activity was tagged depending on what the majority of athletes led by the coach were doing. After the practice session, the lead researcher approached the coach to clarify the type of activity conducted.

The practice activities were categorized as PF, TF, and transition (Table 2). The subcategories were adapted from past studies to suit the multiple sports in this study. The landmark research on PF and TF employed fitness, technique, and skills as subcategories for TF, and small-sided games, conditioned games, and phase of play as subcategories for PF [10]. Not all of these subcategories are suitable for various sports, e.g., games cannot be applied for non-game sports. For this study, no subcategories were used for PF. Rather, PF was defined to encompass open skill activities that simulated competition-like tasks and environment. Contrastingly, TF involves closed skill activities, with technical and physical subcategories similar to those in previous studies. Additionally, detailed definitions were added in each category to encompass all activities in a practice session, as past studies mostly involved only a single sport and did not describe activities such as retrieving equipment (e.g., arrows, balls) or changing players.

Validity and reliability

A panel of 3 experts reviewed the categories and definitions to establish content validity [12, 14]. The experts were 2 skill acquisition academicians with national team coaching background in hockey and athletics, respectively, and a sports performance analyst who served several national teams, with experience in lawn bowling, sepak takraw, hockey, and football. Upon the panel's recommendation, the term 'tactical' was inserted into the PF definition, and each sport was included in the reliability analysis. As multiple sports were involved, the panel found that all items were suitable and representative of practice activities for this context.

The lead researcher and another experienced researcher had been trained to use the performance analysis software and category descriptors that were employed to code and quantify the types of activity [19, 24]. A total of 30% of the observations (n = 18), involving all sports, were checked for inter- and intra-observer reliability [11, 25]. For inter-observer agreement, the lead observer and an independent trained observer watched 6 sessions on their own, at different times within the same week (frequency: intraclass correlation coefficient [ICC] = 0.90, duration: ICC = 0.96). For intra-observer reliability, the lead researcher watched 6 sessions twice, with a 2-week gap between the first and second viewing to allow for a lapse of

Table 2. Types and descriptions of practice activities

Activity	Definition
Playing form	Competitive, open skill activities that could simulate actual competition settings/environment. Activities comprising tactical components include fewer/more athletes, use modified rules, have opponents, involve objective ratings (timing/scoring) and/or standard competition conditions. Any activity conducted in the midst of a playing form task, such as changing players or receiving feedback, is related to, is a necessary part of, or involves learning the playing form task
Training form	Non-competitive, closed skill activities
Technical	Skill-related activities involving technical aspects. Activities not related to fitness or open skills, such as drills, technical skills, practising one part of a skill, repetitive activities with no variation, either alone or in a group. Any activity conducted in the midst of a technical task, such as setting up or collecting equipment, is related to, is a necessary part of, or involves learning the technical task
Physical	Any physical conditioning activities related to fitness aspects of the game and/or to preparing for or recovering from the training session, e.g. warm-up, cool-down, strength and conditioning
Transition	Any inactivity or activities that involve no sport-specific movements, such as resting, water/prayer break, or general briefing

memory [10, 12, 15] (frequency: ICC = 0.99, duration: ICC = 0.99). Intraclass correlations of above 90% indicated an acceptable agreement for both frequency and duration of an activity [7, 23, 24].

Statistical analysis

The time spent on practice activities was computed in percentage, by dividing the duration of the activity by the total duration of the practice session, and then multiplying by 100 [10–12, 14, 17]. Archery, hurdling, and squash were grouped as individual sports, whilst hockey, netball, and volleyball were classified as team sports. Before the inferential statistical tests, Shapiro-Wilk tests indicated that the data were normally distributed ($p > 0.05$). Independent *t*-tests were conducted to compare the practice activities between the groups (individual and team sports), whereas one-way ANOVA with post-hoc Bonferroni was conducted within each group. The effect size was based on Cohen's interpretation: small, medium, large (*d*: 0.2, 0.5, 0.8; : 0.01, 0.06, 0.14). The significance of the results for all tests was set at $p < 0.05$. All analyses were conducted by using the SPSS software, version 26.0 (IBM Corp., Armonk, NY, USA).

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Research Ethics Committee of Sultan Idris Education University (approval No. 2019-0008-01).

Informed consent

Informed consent has been obtained from all individuals included in this study and their legal guardians.

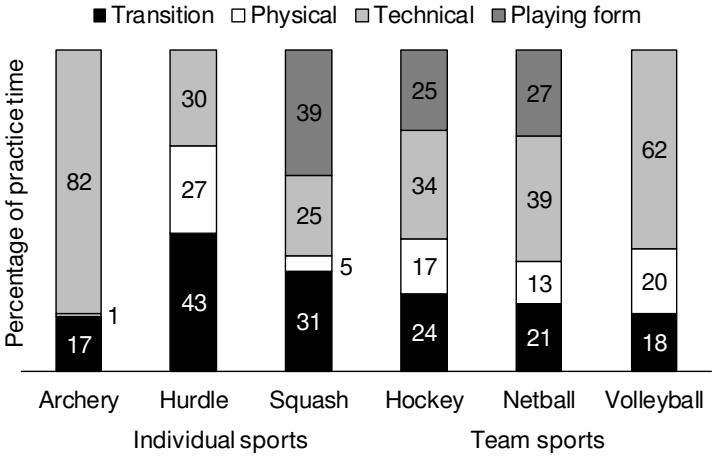
Results

The *t*-tests indicated no difference between individual and team sports for all types of activity (Table 3); PF: t (16) = 0.51, p = 0.62, d = 0.24, 95% CI (–13.69, 22.29); TF: t (16) = 0.48, p = 0.64, d = 0.23, 95% CI (–16.96, 26.89); and transition: t (16) = –1.77, p = 0.10, d = 0.83, 95% CI (–20.37, 1.83).

For team sports, one-way ANOVA presented a significant difference for PF: F (2, 6) = 7.61, p = 0.02, η_p^2 = 0.72; and TF: F (2, 6) = 9.49, p = 0.01, η_p^2 = 0.76. Post-hoc comparison revealed more time devoted to TF in volleyball (M = 82.28, SD = 1.96) compared with hockey (M = 50.76, SD = 15.24, p = 0.03) and netball (M = 51.59, SD = 8.36, p = 0.03). Likewise, volleyball involved no PF compared with hockey (M = 25.44, SD = 12.14, p = 0.05) and netball (M = 27.0, SD = 11.15, p = 0.04). There was no difference for transition between hockey, netball, and volleyball: F (2, 6) = 2.93, p = 0.13, η_p^2 = 0.49.

Similarly, individual sports displayed differences for PF: F (2, 6) = 70.10, $p < 0.001$, = 0.96; and TF: F (2, 6) = 16.71, p = 0.004, η_p^2 = 0.85. Post-hoc analysis indicated that squash involved PF (M = 39.54, SD = 8.18), in contrast to archery ($p < 0.001$) and hurdling ($p < 0.001$). Moreover, squash employed less TF (M = 29.35, SD = 7.13) compared with archery (M = 83.32, SD = 12.13, p = 0.004). There was no difference for transition between archery, hurdling, and squash: F (2, 6) = 3.80, p = 0.09, η_p^2 = 0.56.

Figure 1 shows that 3 sports (archery, hurdling, volleyball) did not involve any PF. Squash players devoted the largest amount of time to PF (40% of session time), followed by netball and field hockey. All



Figures inside the bars represent the percentage of time consumed in each type of activity.
Training form consists of physical and technical components.

Figure 1. Percentage of time spent on practice activities in each sport

Table 3. Average percentage of time devoted to practice activities (mean ± *SD*)

Category	Training form (%)	Playing form (%)	Transition (%)
All sports	59.06 ± 21.44	15.33 ± 17.60	25.61 ± 11.78
Individual sports	56.57 ± 25.38	13.18 ± 20.19	30.25 ± 15.25
Team sports	61.54 ± 17.85	17.48 ± 15.50	20.98 ± 3.77

sports applied technical activity (range of 25–82% of session time), with archery having the highest percentage and squash the lowest. Hurdlers used more than a quarter of practice time on physical activities, which is also the largest amount of time accumulated for fitness-related activity among all sports, whilst squash and archery athletes devoted minimal time to physical activities (5% and below). Hurdlers also spent the largest amount of time on transition activities.

Discussion

The purpose of this study was to distinguish the type and amount of practice activities and determine the usage of PF and TF in multiple sports. When the sports were grouped as individual and team sports, there was no difference between these 2 groups, which supports what was hypothesized. However, when considered individually, each sport presented some specific differences compared with the other sports in this study. Furthermore, all the examined sports utilized TF but some involved no PF at all.

Apart from squash, all sports observed in this study accumulated more practice time on TF compared with PF. The average percentage of time expended in TF and transition activities was comparable with other studies [10–12, 14–16]. However, the mean percentage of time spent on PF was lower than in past studies, including those that predominantly engaged in TF [10, 11, 16]. Among all the sports, squash was the only one that presented analogous volume of PF compared with previous studies [11, 14], although it accounted for less than half the practice time. PF for squash mainly consisted of modified match play (among 3 players).

For some sports, like archery and hurdling, activities during practice and competition are similar, albeit some differences occurred. Hurdlers cleared consecutive hurdles during practice. There were no other competitors, no starting line, and no finishing line. A different number of hurdles at distinctive distances were lined up for various activities, and the speed of execution was slow for some activities. Archers were shooting arrows to a target board. Like hurdlers, archers were not competing with one another. The coaches clarified that they were working on particular technical aspects, which could only be conducted by going through hurdles and shooting arrows in a fixed distance, especially for archers. Furthermore, the archery coach stated that they had scoring sessions (conducted informal competitions) on certain days, but this was not observed. Therefore, there was no PF noted for archery or hurdling.

Similarly, the practice activity observed for volleyball in this study did not involve any opponents, was repetitive, and followed a predicted sequence; thus, it was categorized as TF. Although such an environment makes it easier for the athletes to practise basic skills separately (such as receiving, setting, and spiking), it does not provide the pressure or challenges present during an actual match. For example, a key skill is to spike the ball into the opponent's side of the court but it is easier to do so without potentially being blocked by the opponent. Facing blocks requires practising or playing with opponents. Additionally, volleyball requires both offensive and defensive skills, which necessitates PF. One study identified a volleyball coach who used most time on TF, but still accumulated almost 40% of practice time on PF [11].

The majority of the sports devoted most time to technical activities and least time to physical activity. Fitness trainings were allocated on specific days, 3 out of 9 weekly sessions in some sports. Minimal physical conditioning was applied during the observed practices. Youth development programs may have more elements of technical activities; when younger athletes only need to focus on specific parts of a skill at a time, it is easier for them to pick up particular skills [2, 10]. Moreover, the use of technical activities may be needed at certain times, depending on the current skill status of the athlete and the type of sports. Compared with research that determined a high volume of TF [10–12, 16], archery presented an excessive amount of TF, but this excess may be exclusive for archery and, possibly, other target sports, such as shooting.

In this study, 17–43% of practice time was spent on transition activity. This may appear like a substantial amount of inactive time. However, transition time may be used for different purposes, such as rest or coach feedback. The hurdling event exhibited the highest percentage of time devoted to transition, exceeding that in all previous studies that included transition [11, 12, 14, 15]. Hurdlers utilized a lot of time resting between high-intensity fitness and technical skill activities owing to the physical demands of the event. Squash had the second highest percentage of time consumed on transition. Squash activities were conducted concurrently in multiple individual courts. The coach used break time to provide feedback and instruction when the athletes were gathered. Coaches may designate transition time for learning opportunities [15], although higher skilled athletes may require lesser rest time [8]. The findings from past and present studies suggest that transition activities may vary largely among sports and coaches.

The dissimilar proportions of practice activities (Figure 1) indicate that diverse sports involved a different amount of time for each type of activity. Although there were 3 sports without PF, all these devoted a different amount of time to assorted practice activities, possibly owing to the range of sports that were included here. Archery is a target sport, hurdling is a centimetres, grams, and seconds sport, and volleyball is a net and wall sport. The 2 invasive sports, hockey and netball, presented somewhat similar types and proportions of practice activities, while squash is a racket sport; all of them involved PF. As noted in past studies [7, 11], the most useful activity for each sport differs across sports.

Limitations

Though this study compared various sports, it is important to consider that it focused on practice activities, excluding competition and unstructured activities that are suggested to benefit the development of an elite athlete [4]. Additionally, the activities were tagged as a group, as opposed to individuals. Moreover, the actual time spent on PF and TF would be marginally lower than reported because activities such as changing players or collecting equipment were included in these categories, as explained in the method section. Besides, there was only general discussion with the coaches regarding the distribution of practice time [26]. Also, this study examined 3 sessions per sport, which is the minimum required to observe a coach [19, 23], whereas more sessions may be required to thoroughly inspect the complete practice activities for each sport.

Conclusions

This research presented an analysis of practice activities for multiple sports in a setting of a sports school preparing athletes for elite competition. Past research mainly focused on the importance of PF in game sports, but PF is necessary for most, if not all, sports. The absence of PF in 3 out of the 6 sports in this study highlights the need for more attention on other sports that have not been scrutinized much. It is possible that more sports or coaches have unknowingly excluded or reduced the amount of practice time spent on PF. Although neither PF nor TF have been established as a superior method to develop elite athletes, both types of activities should be utilized during practice. Systematic observations of practice activities allow any such deficiencies to be identified. The findings from this study suggest that coaching pedagogies and the application of coaching methods should be assessed continually. The discrepancies identified during transition activities in past and present studies may require more detailed examination to determine how transition activities can be best employed for different sports. It is also possible that the type of skill acquisition instructions used by coaches affects each sport differently [27]. Future studies should encompass more sports with varying characteristics, such as aerobic and anaerobic sports, involve longitudinal observations to further distinguish the intricacies that envelop the differences between sports, and ensure that what athletes essentially practise is in line with contemporary scientific findings.

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Conflict of interest

The authors state no conflict of interest.

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