

EXPLORING THE COACH'S AND ATHLETES' BEHAVIOUR IN MARTIAL ARTS: A CASE STUDY

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Abstract:

This descriptive study examined the processes of coaching and participation in Brazilian jiu-jitsu (BJJ) for both experienced (n=3) and novice (n=3) adult participants, members of a martial arts club in Finland. Over a period of six weeks, five practice sessions were videotaped with a mean duration of 84.35 minutes. Systematic observation data were used to describe the practice structure and participants' engagement. Additionally, a modified version of the Coach Analysis and Intervention System was used to evaluate coaching behaviour. The heart rate data were also collected to evaluate the participants' physical activity levels. Results indicated that practice time allocated to training and playing were 75% and 25%, respectively, which differs from team sport research. The coaching emphasis observed in this study highlighted competition and technique perfection. The participants' practice activity level was high with most participants spending more than half of practice time at a moderate-to-vigorous physical activity level. These findings show that both the structure and content of coaching practice is context specific and that the coach need to identify and react to the needs of individual athletes.

Key words: *coach behaviour, athlete activity, systematic observation, martial arts*

Introduction

In order to understand coaching and to develop coach education, a significant body of research has been conducted during the last decade focused specifically on coach behaviour in the coaching context (Gilbert & Trudel, 2004; Harvey, Cushion, Cope, & Muir, 2013). In the process of examining coaching behaviour in the coaching context, one accepted line of research is the use of systematic observation tools to describe coaching behaviours. The coaching education literature has produced consistent results about coaching behaviour where coaches most frequently instructed, provided feedback and encouragement as well as managed the training environment (Cushion & Jones, 2001; Ford, Yates, & Williams, 2010; Harvey, et al., 2013). The pattern of the coaching behaviour can be understood as a sequential cycle of unplanned and reactive behaviours (Kahan, 1999). Turnnidge, Côté, Hollenstein, and Deakin (2014) reported that the most frequently occurring coaching behavioural sequence was observation followed by organization. During the observation phases, coaches need to recognize and analyse what athletes are doing. However, the relationship between coach's behaviour and concurrent or subsequent athletes' activity is relatively under-researched.

The structure and content of coaching sessions vary between different sports and contexts (e.g., differing situations of competition, organization, and training; Cushion, Harvey, Muir & Nelson, 2012). Furthermore, within practice sessions, various instructional strategies might be utilized to provide appropriate instruction to different individual athletes (Erickson, Côté, Hollenstein, & Deakin, 2011). In analysing coaching behaviour in ball games, researchers (Ford, et al., 2010; Hall, Gray, & Sproule, 2015; Harvey, et al., 2013; Partington & Cushion, 2013) categorized practice activities into "Training Form" (e.g., warm-up, physical conditioning practice, technique and skills practices) or "Playing Form" (e.g., game played in different forms) in order to compare practice content.

Most studies in coaching settings have compared high and low ability athletes from different but homogenous teams (Ford, et al., 2010; Partington, Cushion, & Harvey, 2014). Only one study has looked at competitive and recreational level athletes in the same practice group (Turnnidge, et al., 2014). These and other findings (Hüttermann, Memmert, & Baker, 2014) show the specific nature of coaching, where behaviours varies from coach to coach and between sporting contexts. Consequently, it is

important to consider the coaching context that many researchers have taken into consideration when they developed sophisticated and activity specific observation instruments (Cushion, et al., 2012; Hall, et al., 2016).

Martial arts coaching

While researchers have studied a variety of sports and levels, most coach education research is related to team sports in ball games from the college, high school and youth sport contexts (Cope, Partington, & Harvey, 2017; Gilbert & Trudel, 2004; Kahan, 1999). Research related to coaching in individual sports and particularly about the coaching behaviours of martial arts coaches is limited. An expansion of the knowledge base of coaching in martial arts could contribute to the development of a more comprehensive understanding of coaching practice, as advocated for by Vertonghen, Theeboom, and Cloes (2012).

Although coaches/instructors typically notice the positive influence that martial arts have on the participants, others argue that martial arts practice among adolescents can be problematic (Vertonghen & Theeboom, 2013). In martial arts instruction, the coach has a central role, particularly when employing an eastern coaching method that emphasizes learning through exhaustive repetitions with the goal of producing technical perfection instead of understanding why the skill is important and how it can be applied (Avakian, Suoto Morine, & Franchini, 2011). This authoritarian (direct) coaching approach was evident in the d'Arripe-Longueville, Fournier, and Dubois (1998) study through in-depth interviews of judo participants. Moreover, Vertonghen et al. (2012) identified three different coaching styles (traditional, sporting, and efficiency) by observing and interviewing martial arts coaches. The traditional approach focuses on often used aspects and pedagogy in martial arts. The sporting approach still emphasizes traditional aspects but considers martial arts as a sport. In the efficiency approach the concentration is on competition and effectively performing a technique. Although these studies provide a glimpse into the martial arts coaching, nevertheless Vertonghen and Theeboom, (2013, p. 248) described martial arts studies having "a 'black box' perspective, [where] the measurement of the outcomes of martial arts involvement is emphasised, while the context and processes that take place are not examined and remain somewhat mysterious".

A focus on the athlete

To date the use of systematic observation protocols has provided a significant amount of information concerning the coach's behaviour; however, this data is somewhat limited in nature as the focus

is only related to direct styles of coaching and the behavioural aspects of the coach. This is a clear limitation of the current coaching behaviour literature, when the coaching process is viewed as unidirectional (Kahan, 1999). Current research has mainly focused on coaches' behaviours that influence athletes' experiences, without accounting for how athletes can actively impact the coaching process. Turnnidge et al. (2014) proposed that examining athletes' behaviours as well as coaches' behaviours might contribute to a more in-depth understanding of the whole coaching process. Accordingly, information on coaching behaviour needs to be supplemented with data about athletes' participation in practice.

There is a gap in the coaching literature related to how athletes spend time in the practice of motor skills in sporting context. However, two studies from team as well as individual sports (Smith, Ward, Rodrigues-Neto, & Zhang, 2009; Turnnidge, et al., 2014) showed that athletes were engaged at high levels. In addition, more information can be provided through the evaluation of frequency of trials relative to athlete learning (Smith, et al., 2009). Using trials as a variable provides information and knowledge about the number of times athletes performed the skill and their success rate. When athletes' success rate is high, there is an assumption that coaches' practice tasks are at an appropriate level for the athletes (Rink, 2002). In analysing both time and trial data, Smith et al. (2009) noted that the trial data from on-the-ball behaviour showed a low engagement rate compared to the time based data, which suggests the use of multiple data sources.

In both soccer (Hill-Haas, Dawson, Coutts, & Rowsell, 2009) and basketball (Klusemann, Pyne, Foster, & Drinkwater, 2012) researchers have examined how athletes' physiological and technical demands interact with the number of players involved, court size, and work-to-rest ratio. However, in these studies, the practice context was isolated almost to a laboratory level and the environment was not ecologically valid (Davids, 1988), which in traditional coaching happens when coaches do different things and interact with their athletes. Another study performed in a decontextualized setting, examined athletes' trials and similarly players' success or efficiency in terms of percentage of correct performances (Conte, Favero, Niederhausen, Capranica, & Tessitore, 2016). However, when athletes participate in similar activity contexts, there are differences between individual athletes. In general, more experienced athletes possess a significantly higher rate of procedural knowledge and more elaborated and sophisticated tactical knowledge (García López, Gutiérrez Díaz del Campo, Abellán Hernández, González Villora, & Webb, 2010). In martial arts, Mori,

Ohtani, and Imanaka (2002) reported that experts had faster reaction times and a higher percentage of correct responses compared to beginners, suggesting that experts were able to better read the opponent's movements. Finally, Silverman, Subramaniam, and Woods (1998) found in the physical education context that the more skilled students had more attempts and a larger proportion of successes compared to the average and low skilled students.

Another physiological performance outcome, heart rate (HR), has also been used in sporting context to describe intensity of athletes' practice effort. In youth basketball, training intensity expressed as %HRmax are reported as 85% to 88% in practice drills (Conte, et al., 2016; Klusemann, et al., 2012). In martial arts contexts, researchers have reported in karate a 97% HRmax in sparring combats (Imamura, et al., 1996) and during practice in taekwondo 64.7% – 81.4% HRmax (Bridge, Jones, Hitchen & Sanchez, 2007). In Brazilian jiu-jitsu (BJJ), athletes showed, after a simulated competition, an average HR of 165 bpm or higher (Andreato, et al., 2012; Villar, Gillis, Santana, Pinheiro, & Almeida, 2018). Once more, these studies have utilised physiological outcomes and there is no connection to the context and/or how coach's behaviour impacts the practice.

Consequently, the main purpose of this study was to contribute to the existing martial art coaching database by providing descriptive data relating to the coaching processes during martial arts practice. Therefore, the specific purpose of the present study was to conduct an in-depth case study of one BJJ coach and his athletes. More precisely, in this study we wanted to address the following three research questions: (a) How did the coach structure the practice session?; (b) What kind of coaching behaviours were prevalent in this context?; and (c) How active were athletes during the practice sessions? A secondary purpose was to compare coach and athlete behaviour in relation to athletes' level of experience. Even though this case study was exploratory and descriptive, we hope that the initial work with combining coach and athlete behaviours will inspire further research into the coaching processes of martial arts and advance our understanding and knowledge in martial arts coaching and sports coaching in general.

Methods

Participants and setting

The participants in this study were recruited from a local martial arts club located in the west of Finland. The study context could be described as a recreational domain of coaching with an emphasis on participation, basic skill development, formal organization, and low commitment (Trudel & Gilbert, 2013). This club was purposefully selected

for its diverse range of athletes who train with the same coach. By evaluating the practice sessions of one coach and a diverse range of athletes, this study provided a unique opportunity to increase our knowledge about the martial arts coaching process. The male coach Peter (pseudonym) was 36 years of age, with eight years of training experience and five years of coaching experience. He had a brown belt and was therefore able to teach the BJJ to others. The athletes ranged in age from 14 to 35 years: 20 years and under ($n = 3$), 21–30 ($n = 27$), and 31 and over ($n = 6$). All participants were provided with the information related to the aim of the study, research procedures, requirements, and they all gave informed consent. The club also provided a written permission for the study. The subjects' experience of martial arts ranged from three months to six years and from white belt to purple belt level. Three experienced (28, 29 and 35 years of age) and three novice (21, 26 and 31 years of age) athletes (based upon their experience of BJJ practice and belt level) were identified with the help of the coach. All three novice athletes had a white belt. Two of the novice athletes had three months of practice experience, whereas the third novice athlete had six months of practice experience. The experienced athletes all had blue belts and had three, five, and five and a half years of experience. Athletes' attendance at practice sessions varied from 14 to 19 in each session because this was a leisure time martial arts club. Similarly, neither experienced nor novice athletes participated in all practice sessions during this study. This martial arts group usually practiced twice a week and they had one weekend practice camp during the duration of the study.

Practice sessions typically lasted 90 minutes and were organized to include a warm-up phase, followed by skill practice and culminating in a sparring phase. These three phases were comparable to how practice activities were organized in previous coach education research, where activities were categorized into either "Training Form" (e.g., warm-up, physical conditioning practice, technique, and skills practices) or "Playing Form" (e.g., game played in different forms) (Ford, et al., 2010; Hall, et al., 2016; Harvey, et al., 2013; Partington & Cushion, 2013). In this study, "Training Form" was divided into two categories: warm-up and skill practice. During the warm-up, athletes individually and/or in pairs performed routine and fitness-related tasks with a goal of preparing for the skill practice. The skill practice consisted of both easy and difficult tasks where different competition-simulated techniques were practiced in pairs or groups of three. Although some forms of structured competition simulations were counted to skill practice, the coach provided pre-instructions about the techniques to be used, but the athletes themselves had to determine when and how to use them. "Playing

Form" or sparring was defined as practice combats between athletes at the end of each practice session.

Procedure

Data were analysed through systematic observation during three viewing (stages) of videotaped practice sessions. This facilitated an in-depth analysis of all participants in this practice setting. The second author, with the expertise in BJJ, was the main observer and was trained by first reading the definitions of all variables. Then he discussed the definitions with the first author, an experienced researcher. Finally, they then together observed one video-taped practice session and discussed the coding. A pilot work was also done with the instrument to verify categories through preliminary observations by a different BJJ youth coach.

The observations for the study were conducted by the second author, who visited the practice sessions for a period of six consecutive weeks between March and April. A total of five practice sessions (session durations averaged $M=84.35$ minutes [$SD=5.53$]) were observed and recorded. This is 422 minutes of behavioural observation, which exceeds the three coaching sessions of 90 minutes that has been established as a sufficient amount to observe in coaching education research (Brewer & Jones, 2002; Cope, et al., 2017).

Two digital video cameras were positioned in the two opposite corners of the practice facility and each camera recorded half of the practice area. A synchronized small clip-on microphone was attached to the coach for the recording of the sound and was connected to one camera. The researcher positioned himself away from the practice area in a nonobtrusive location. Videos were subsequently downloaded onto a computer after every practice session and analysed using the three stages of viewing. However, technical problems as well as signal interference prevented clear and unobtrusive recording of audio during the first practice session and therefore the analysis of coach behaviour during warm-up and skill practice was omitted from this first practice session. Similarly, when heart rate data for each athlete was downloaded, athlete files that did not contain any data due to context specific connection problems were excluded from this practice session.

Time in practice sessions. The structure from task analysis instrument (Romar, 1994; Siedentop, Doutis, Tsangaridou, Ward, & Rauschenbach, 1994) was used to describe how athletes spent their time in practice sessions. This instrument describes how coaches organized practice sessions in the following categories: management, instruction, and motor activity (see Table 1 for definitions). The first stage of data analysis included an analysis of coaching activities with a duration recording method (Darst, Zakrajsek, & Mancini, 1989), where the start and

end times of each activity type was recorded. Motor activity was in this study divided into two categories based on how the coach supervised the practice; he was either observing and providing feedback, or participating himself in the activities as a role model or sparring an individual athlete. The analysis allowed the observers to view the elements of a practice session and determine the amount of time spent in practice phases and practice categories.

Coach behaviour. The second stage of analysis focused on coach behaviour. The systematic observation instrument used for recording coach behaviour data was a modified version of the Coach Analysis and Intervention System (CAIS) (Cushion, et al., 2012). The CAIS has a total of 23 specifically defined behavioural categories. However, in line with Harvey et al. (2013) and Partington et al. (2013), studies examining coaching behaviour, this study focused on 11 key coach behaviours within the original CAIS instrument (see Table 1 for definitions). In addition, secondary behaviours related to content and receiver provided another dimension. An adjustment was made to the definition of "questioning" category. This adaptation consisted of recording instances when the coach asked athletes verbal questions as well as when the coach was asked a question by an athlete and when the coach responded to the question. Data were recorded using event recording (Darst, et al., 1989) where each time an identifiable and pre-defined behavior was observed, including any change in behaviour, a record was entered on the coding sheet. Coach verbal behaviour data were collected during warm-up and skill practice phases. During the sparring phase of practice, as the coach actively participated in combative activities, he was unable to wear the remote microphone.

Athlete data. A unique feature of this study was that in addition to how the coach structured practice and instructed and interacted with the athletes, trial and heart rate data were also collected in a coaching setting. For each individual athlete, their opportunities to practice (trial attempts) were measured during the skill practice phase. The rationale for this decision was that skill learning is the major focus in effective coaching literature (Hodges & Williams, 2012). Similarly, athletes' intended task focus on their performance was impossible to determine during sparring and therefore this phase was not included in the analysis. Skill practice tasks are often performed in pairs in BJJ where one athlete is in the role of an attacker and the other of a defender. Both are equally active and perform opposing roles within the same task. The coach provides instructions to both athletes about what to do during practice to simulate a bout situation, where techniques are applied in a competitive context. In the skill practice tasks, it is always one athlete that must be successful with his technique while the other

Table 1. Definitions of terms for practice phases, content categories, coach behaviour, and trial data

Categories	Definitions
Warm-up	Routine- and fitness-related tasks with a goal of preparing for the skill practice, individually or in pairs.
Skill practice	Tasks where different match techniques were practised in pairs or groups of three and the coach provided instructions about the technique to be used.
Sparring	Practice combats between athletes at the end of each practice session.
Management	Content related to organizing athletes and equipment.
Instruction	Content related to the coach providing instructions and demonstration of practice tasks.
Activity a	Content related to motor activity where the coach was observing and providing feedback.
Activity b	Content related to motor activity where the coach participated himself in the activities as a role model or sparring an individual athlete.
Instruction	Information given to athletes about tasks, skills, and strategy.
General feedback positive	Verbal or non-verbal general positive information about the athletes' performance.
General feedback negative	Verbal or non-verbal general negative information about the athletes' performance.
Specific feedback positive	Specific verbal communication about what was correct in the performance.
Specific feedback corrective	Specific verbal communication about errors in the performance including feedback aiming at improving performance execution.
Positive modelling	A demonstration of a correct performance of a skill or strategy, alone or together with an athlete.
Negative modelling	A demonstration of an incorrect performance of a skill or strategy, alone or together with an athlete.
Physical assistance	Physically moving an athlete to the correct position or through the correct range of movement.
Questioning	Any questions to athletes or listening and responding to athletes' questions, unless falling under instruction or feedback.
Praise	Compliments and statements about general behaviour, such as attitude and effort.
Scold	Displeasure about general behaviour.
Hustle	Verbal statements aimed at intensity effort.
Management	Organising the practice, arranging equipment and athletes.
Humour	Jokes or content designed to make players laugh or smile.
Uncodable	Any behaviour that did not fit into the other coach behaviour categories.
Correct trial	The athlete's performance is consistent with the correct execution of the skill as described and demonstrated by the coach.
Incorrect trial	The athlete's performance is not consistent with the correct execution of the skill as described and demonstrated by the coach.
Trial/min	The total number of skill performances during practice time in the skill practice phase.

will fail. Therefore, we categorized the performance as a trial when the athlete made an attack. We chose to analyse the number of attacks for measuring the trials, as the defending athlete by definition cannot succeed in the BBJ context. Some complex tasks also contain several elements which could be judged as independent performances, but in this study, we chose to analyse the performance as a unit where the outcome determined if the athlete was successful or not. In this analysis, the total number of trials indicated the opportunities each athlete had to perform the stated skill. In addition, the successful performance of these tasks was coded according to the criteria stated by the

coach in his task instructions. One experienced, one novice athlete, and one representing the other athletes were randomly selected for observation for one practice task. During that task, the number of athletes' trials and success was recorded. After the end of the task, another athlete from each group was selected and observed. Athletes who were not observed would be identified for the next observation. This process would continue until the skill practice session was completed.

In addition to practice opportunity and success monitoring using trial analysis, practice intensity levels during each session were also measured using Polar heart rate monitors (Team System 2, Polar,

Kempele, Finland). Athletes placed a HR monitor belt onto their chest whilst entering the practice facility prior to each practice session. A maximal Fitness Test was administered to assess athletes' HRmax at the end of the first practice session as an additional task. The test protocol involved athletes performing fitness activities (jumps and arm presses) with the goal to complete as many as possible. The test ended when the athletes could no longer perform the task and the heart rate at that time was registered as HRmax. Exercise intensity during each practice phase (warm-up, skill practice, and sparring) was assessed using heart rate, expressed as a percentage of HRmax and classified into two previously defined intensity zones: Moderate-to-Vigorous Physical Activity (MVPA, 60–100% HRmax) and Vigorous Physical Activity (VPA, 80–100% HRmax). These zones were selected because young adults often have health-oriented (MVPA) and fitness-related (VPA) motives for leisure time sport participation (Kilpatrick, Hebert, & Bartholomew, 2005). Both the actual and percentage time spent in each zone for each athlete were recorded.

Data analysis

The length of each practice session was recorded, and the duration and proportion spent in each of the three practice phases and four content categories (Table 2) was subsequently calculated. The time variables for each practice session were summed and divided by the total number of sessions to determine the mean percentage of time spent in different phases and content categories across all sessions. Coach behaviour data were coded and quantified for each behaviour category. Overall totals, percentages, and rate per minute for each category were calculated and summed. The rate per minute for each behaviour was calculated by dividing the total for each category by the total number of minutes observed. Coach behaviour studies have frequently reported findings in terms of percentages (Cope, et al., 2017; Partington & Cushion, 2013) and it was recommended to be a reliable variable (Ford, et al., 2010). At the secondary level, coach attention to individual either experienced or novice athletes

was computed by dividing total coach behaviours specifically towards these athletes by the number of athletes who participated in practice sessions. Valid heart rate data from athletes representing different groups (other, experienced, novice) were calculated as group average for phases of each practice session and mean percentage of time spent in MVPA and VPA during sessions was totalled. Finally, descriptive statistics were calculated for frequency of practice trials by experience.

Intra-observer and inter-observer agreement checks were calculated for 20 % of randomly selected practice sessions. For intra-observer agreement, the second author analysed the video on two separate occasions with at least a two-week gap for memory lapse to occur (Darst, et al., 1989). The first author served in analysing inter-observer agreement for time and coach behavioural data and the coach assisted in inter-observer agreement checks for trial data. Both the inter- and intra-observer agreement for this study exceeded the determined criterion, the overall mean was 91.6% (range 85.3% to 96.3%) (van der Mars, 1989).

Results

Practice structure

The average length of practice sessions was 84.35 minutes and warm-up accounted for an average of 33.2%, skill practice of 41.0%, and sparring of 25.8% of the practice time (see Table 2). The three practice phases had a different structure. During warm-up, the coach spent most of the time in observing and participating in practice activities with little time devoted for management (6.2%). In skill practice, the coach mostly observed with providing feedback and explained the skills, while he rarely participated in the activity (0.4%). During sparring phase, the main focus of the coach was on the organisation and participation of athletes in the combative activities. Overall, the coach provided time for athletes to practice (motor activity) was on average 54.34 minutes (64.4%), then he provided instruction for 20.08 min (23.8%) and managed practice for 9.94 min (11.8%) during the BJJ practice sessions.

Table 2. Mean proportion of practice time by practice phases and content category

	Warm-up			Skill practice			Sparring		
	M	SD	%	M	SD	%	M	SD	%
Instruction	7.40	3.03	26.5	12.02	4.83	34.8	0.66	0.87	3.0
Management	1.75	1.31	6.2	3.31	1.21	9.6	4.88	0.37	22.4
Activity a	10.51	6.72	37.6	19.11	4.12	55.2	0.82	1.72	3.8
Activity b	8.32	3.97	29.7	0.15	0.27	0.4	15.43	2.98	70.8
Total	27.97		33.2	35.60		41.0	21.78		25.8

Coach behaviour

Results showed a total of 784 coach behaviours recorded during 422 min of practice sessions. In terms of the coach's verbal interactions per minute with the athletes, his rate of interaction per minute during warm-up was twice that of his verbal interaction rate during skill practice. Five coach behaviours ("instruction", "positive modelling", "specific feedback negative", "management", and "general feedback positive") comprised about 73% of all behaviours totalled in the warm-up and skill practice phases. Of these, "instruction" was most frequently

employed in both the warm-up and skill practice phases (see Table 3). "Positive modelling" was the second most used behaviour overall, however employed more in warm-up than during skill practice. The proportion of "management", "specific feedback corrective", "physical assistance", and "questioning" was higher in the skill practice phase, while "praise" had higher percentage and RPM in warm-up. In addition, novice athletes received a higher proportion of coach individual attention through more "general feedback positive", "specific feedback corrective" and "physical assistance".

Table 3. Coach behaviour during warm-up and skill practice (total behaviours, percentage of behaviours [mean] and rate per minute [RPM]) and individual interactions with experienced and novice athletes

	Warm-up			Skill practice			Expe.	Novice
	Total	%	RPM	Total	%	RPM		
Instruction	140	29.79	1.00	69	21.97	0.40	0.82	0.625
Gen feedback pos	43	9.15	0.31	32	10.19	0.18	0.27	0.75
Gen feedback neg	0	0.00	0.00	0	0.00	0.00	0	0
Spec feedback pos	4	0.85	0.03	5	1.59	0.03	0	0
Spec feedback corr	47	10.00	0.34	46	14.65	0.27	0.91	2.125
Positive modelling	70	14.89	0.50	29	9.24	0.17	0.45	0.25
Negative modelling	10	2.13	0.07	6	1.91	0.03	0.09	0
Physical assistance	23	4.89	0.16	28	8.92	0.16	0.27	1.625
Questioning	21	4.47	0.15	30	9.55	0.17	0.45	0.625
Praise	51	10.85	0.36	7	2.23	0.04	0	0
Scold	0	0.00	0.00	0	0.00	0.00	0	0
Hustle	2	0.43	0.01	1	0.32	0.01	0	0
Management	44	9.36	0.31	49	15.61	0.28	0.45	0.25
Humour	8	1.70	0.06	6	1.91	0.03	0	0.125
Uncodable	7	1.49	0.05	6	1.91	0.03		
Total	470	100	3.36	314		1.82	3.73	6.375

Table 4. Mean (% + SD) of athletes' moderate-to-vigorous physical activity (MVPA), vigorous physical activity (VPA), and trials in skill practice by athletes and practice phase

	Experienced		Novice		Other	
	M	SD	M	SD	M	SD
MVPA %						
- Warm-up	51.20	32.14	74.40	14.66	46.50	12.87
- Skill practice	54.40	32.60	80.40	21.09	53.00	14.07
- Sparring	83.40	12.82	90.80	12.28	92.00	4.32
VPA %						
- Warm-up	7.60	5.86	8.60	5.37	3.50	2.89
- Skill practice	9.60	8.62	12.20	9.34	3.00	2.71
- Sparring	34.20	22.87	73.70	17.70	65.50	10.47
SKILL PRACTICE						
Correct trials	26.40	14.74	17.80	12.36	21.00	14.00
Incorrect trials	0.60	1.34	3.8	4.44	4.00	2.74
Total trials/min	1.41		1.12		1.30	

Athlete participation

As shown in Table 4, athletes from all groups showed a high proportion of VPA intensity during sparring. Experienced athletes (34.2%) showed a lower proportion of VPA intensity during sparring compared to novice (73.7%) and the other athletes (65.5%). Athletes' average MVPA across the three phases exceeded for all the athletes almost half of the practice time with average MVPA levels ranging from 46.5% for other athletes in warm-up to 92.0% for the same athletes in sparring. In addition, experienced athletes had more correct and less incorrect trials compared to novice as well as all other athletes. Novice athletes had lower total trials per minute compared to experienced and all other athletes.

Discussion and conclusions

The purpose of the present study was to examine both the coach and athlete behaviours in a BJJ context where athletes had various levels of experience in this sport. While being aware of the restricted generalizability of a case-study approach, findings in this study describe a contextualised practice setting that is different from the traditional coaching practice presented in the literature (Cope, et al., 2017; Kahan, 1999). Data in this study indicated that the coach structured practice sessions into three phases, where one third was warm-up, about 40% skill practice and one quarter was used for sparring. In terms of broadly classifying, where warm-up and skill practice are defined as Training Form (75%) and sparring as Playing Form (25%), the picture of BJJ practice is different from team sport research (Hall, et al., 2015; Hüttermann, et al., 2014; Partington & Cushion, 2013), where a small difference between "training" and "playing" forms of practice has been reported, often in favour of "playing" form. Our results are more closely aligned with Ford et al. (2010) who noted a ratio of 65% to 35% of time in 'training' and 'playing' form practice, respectively. Though speculative, we can find several explanations for the way the BJJ coach structured his practice sessions. First, from observing the coach, his teaching style in martial arts would be best categorized as an efficiency approach, where the focus is on competition and effectively performing a technique (Vertonghen, et al., 2012). Secondly, research in martial arts (Bujak, et al. 2013) reported that coaches indicated physical preparation and learning movement skills as the most important activities in coaching practice. Third, HR data showed that athletes' participation intensity was at a high level during the sparring phase, which physiologically might be impossible to sustain for a prolonged time. Consequently, time for sparring is shorter and therefore more time is devoted to skill practice where athletes are physi-

ologically ready to focus on skill learning. Finally, another explanation for different findings might be related to method of categorisation and data collection used in previous studies. Therefore, these findings further support the notion that the structure and content of coaching practice will naturally vary between different sports in the practice context (Hüttermann, et al., 2014).

The efficiency approach with an emphasis on competition and effectively performing a technique might also be reflected in how the coach structured time for content categories as activity, instruction, and management. Athletes were supposed to actively practice about two thirds, while instruction accounted for one fourth and management time was 10% of the practice sessions. Athletes' activity time percentage was higher when compared to activity time percentages in most physical education classes (Siedentop & van der Mars, 2004). However, Harvey, Song, Baek, and van der Mars (2016) reported comparable lesson percentage proportions for activity, instruction and management during a soccer unit with a game-centred approach where students were engaged in game play for most of the lesson. Recently, a few existing studies in coach education have showed that athletes in individual as well as team sports were engaged at a similar high level as in this study (Harvey, et al., 2013; Smith, et al., 2009; Turnnidge, et al., 2014), though their data were obtained with different instruments. Much of the explanation for our data lies in the BJJ context with motivated athletes and a competent coach whose content and pedagogy expertise along with his coaching experience resulted in well-organised practice sessions. The data suggest that a combination of the coach's active instruction and athletes' high activity time provided athletes with opportunities to learn new and develop previous skills in BJJ. Therefore, for coaches wanting to develop a learning environment where athletes improve, activity time is important, but time is also required for instructing (informing athletes what and how to practise) and managing practice. Moreover, in absence of literature on time spent in the practice of motor skills in (youth) sport context, our findings could act as a guideline of how practice sessions are structured in martial arts and particularly in BJJ.

As expected from previous research (Hall, et al., 2016), the coach showed a different content structure during the three practice phases. During the warm-up phase of the training session, the coach participated in and concurrently observed the warm-up activities. In skill practice he instructed and observed. During the sparring portion, he focused on individual athletes by participating in combats. The proportion of time devoted to each practice phase was most similar to the traditional coaching reported in previous research (Cushion & Jones, 2001; Harvey, et al., 2013; Turnnidge, et

al., 2014), where coaches employed sequences of observation followed by positive reinforcement, technical instruction with modelling, or general communication to individual athletes. In this BJJ context however, the allocation of time reflected a different picture of coaching, where the coach, during warm-up, participated in the same fitness activities as the athletes in order to model correct movements and inspire the athletes. The coach role was also different during sparring from the traditional coaching behaviours. He participated in combative sparring with individual athletes, where he could concurrently evaluate and challenge their performance. Here the emphasis was on individual athletes and the rest of the group participated in combative activities with their partners. This might be a functional approach in the BJJ context, where athletes are motivated to learn and apply their skills as well as to have a “tough” workout. This sport-specific finding also encourages researchers to continue to be context sensitive when adopting a particular observation instrument to an under-researched sport (Cope, et al., 2017; Cushion, et al., 2012).

It is important to keep in mind the above discussion when interpreting data from the coach behaviour analysis. This BJJ coach confirmed commonly exhibited coaching behaviours in previous research (Cushion & Jones, 2001; Hall, et al., 2016; Turnnidge, et al., 2014), in which instruction and management were important elements of effective coaching. However, the coach's behaviour was found to vary depending upon the practice phase. Overall, he interacted more frequently during the warm-up phase than during skill practice. Particularly positive modelling, instruction and praise had a higher proportion compared to other observed behaviours. This result might be related to the fact that the coach presented many different instructional tasks in a rapid succession, showed and modelled the activity and participated himself (Avakian, et al., 2011). On the other hand, during the skill practice phase, the coach organised athlete practice for an extended period of time on one particular skill and therefore he frequently provided feedback with a focus on skill improvement (specific corrective feedback), physical assistance and questions. Consequently, it could be argued that the coaching was formed by the context, even though the previously reported dysfunctional coaching behaviour of an authoritarian approach was not apparent (d'Arripe-Longueville, et al., 1998). The established climate during both warm-up and skill practice demonstrated the effective teaching style that the coach strived for and was evident in the observed practice sessions. Therefore, when structure and content in coaching practice differ, these findings challenge a simplistic assumption that one kind of coaching behaviour is superior over the other. Instead, it is

more about how each activity is designed and implemented, that will define the significance for athlete improvement (Hall, et al., 2016).

Given our results about differences in the structure and content in the BJJ practice, the coach's behaviour also varied in how he interacted with athletes with different experience. The novice athletes received higher levels of individual attention from the coach in comparison to experienced athletes, contrary to previous findings (Turnnidge, et al., 2014). The specific coach behaviours were in the form of a more frequent physical assistance, and skill improvement feedback as well as encouraging feedback. While the novice athletes had only a few months of BJJ experience, it is understandable that they needed physical assistance about the movement to understand and to be able to perform the practice skills. This finding, where the coach frequently employs physical assistance to help athletes learn, has not been reported in previous coaching research (Cushion & Jones, 2001; Harvey, et al., 2013) and thus it is one of the least used coaching categories. This might be related to the different context and culture, where the focus is on combatting against another person with body contact and reacting to the opponent, and thus physical assistance is necessitated to support learning. The extensive use of physical assistance, particularly to novice athletes, and the high levels of coach's corrective and positive reinforcing feedback, indicate a desire by the coach to create a positive coaching environment for all athletes (Turnnidge, et al., 2014).

A unique aspect of this coaching study was the examination of athletes' practice involvement. Based on our HR data and when proportion of practice session time engaged in MVPA was used as the measure of physical activity, most athletes spend about half or more of the practice session being physically active at the MVPA level. These data from a recreational domain of coaching suggest (Trudel & Gilbert, 2013) that athletes are actively participating in BJJ practice, particularly compared to student MVPA level in physical education, when reviews have noted that students are physically active for about one third to 45% of the physical education lesson time (Fairclough & Stratton, 2006). Furthermore, literature suggests that physical activity is associated with abundant health benefits and a public health guideline for physical activity encourage youths to engage in a minimum of 60 minutes per day of MVPA. In the current study, not only did athletes meet guidelines for MVPA, the sparring phase showed a very high proportion of high intensity (VPA) for all athletes, which means that athletes had an opportunity to increase their cardiorespiratory fitness level (Drenowatz, Prasad, Hand, Shook, & Blair, 2016; Gralla, McDonald, Breneman, Beets, & Moore, 2019). It is possible that the characteristics and aims of the practice

tasks provided athletes with an opportunity to engage in the whole body movements using large muscle groups, which in turn is seen in their practice intensity. Moreover, our HR data during the sparring phase are comparable to those observed in other coaching research utilizing simulated and real combat in martial arts (Andreato, et al., 2012; Bridge, et al., 2007; Imamura, et al., 1996; Villar, et al., 2016) as well as in basketball practice (Conte, et al., 2016; Klusemann, et al., 2012). Accordingly, sparring in BJJ is essentially an ongoing practice form that provides good opportunities for intense physical activity.

While coach activity time and HR data for skill practice showed high opportunities for practice and high involvement, the analysis of the trial data show that athletes did not have similar opportunities for practice. There are two things that are interesting. First, this is not a very high practice rate, it was on average about one attempt per minute. This finding needs to be related to the context. On the one hand, our data captured an offensive skill attempt, where the offensive athlete tried to combat his/her partner. Typically, after one attempt, athletes switched from being an attacker to a defender, and the athlete was active although it was not coded as a practice trial, and similarly hiding the fact that the athletes have been on-task during skill practice. On the other hand, our data reflect the specificity of the BJJ practice where athletes practise their skills in pairs by taking turns compared to hitting a golf ball, tennis ball or shooting a basketball or soccer ball, which does not take any significant amount of time and/or physical effort to complete.

However, now we do not know if the engagement rate is high or low compared to other sports. A few studies have reported data on players' engagement rate in varied game practice situations, although these sports are different compared to BJJ. In basketball, athletes had between 1 to 2.5 passes per minute and additionally 0.7 to 1.9 shots per minute, giving a total of 2 to 4 skill actions (Conte, et al., 2016; Klusemann, et al., 2012) and in soccer the frequency of ball possession ranged from 0.4 to 1.7 per minute (Smith, et al., 2009). Taking the context in consideration, the conclusion is that our findings might represent the higher end of practice engagement. Nevertheless, given that the novice athletes showed higher MVPA and VPA levels across all practice phases compared to all other athletes, it is interesting to note that the results revealed they had fewer total and correct trials.

Thus, particularly experienced athletes showed a higher engagement rate (Silverman, et al., 1998), indicating that their experience helped them to higher levels of actual skill practice. Although it is uncertain why this might be the case, it might be that experienced athletes can develop and plan their practice selection through their knowledge base that increases with experience and expertise (García López, et al., 2010; Mori, et al., 2002). This finding indicates, in addition to the context specificity of coaching behaviour, that coaching is about identifying individual athletes' performances and needs and reacting in a balanced way to find productive outcomes (Erickson, et al., 2011).

Taking these engagement rates in consideration, the success rate (correct trials/total trials) for athletes were typically above 82.4% (novice athlete) and for the experienced athlete as high as 97.8%. Given the few studies in coaching, young basketball players success rate varies from passing (easy skill) with about 90% to shooting (difficult skill), where success rate ranged from 26% to 40% depending on practice conditions (Conte, et al., 2016) and in junior soccer a successful rate of ball possession between 58% to 83% for individual players (Smith, et al., 2009). Thus, in the current study, athletes showed a very high success rate and thereby provided evidence that skill practice tasks were at an appropriate level of difficulty (Rink, 2002). Generally, studies report a positive relationship between correct practice and learning (Silverman, 1993).

The lack of research in this area makes the present study unique and it represents the first step in the concurrent use of both the coach and athlete behaviour data. Similarly, it has lifted the lid of the "black box" and shed some light about the context and processes that take place in martial arts coaching (Vertonghen & Theeboom, 2013). This current study was not without limitations, the most significant being that it was a descriptive study conducted in one BJJ coaching setting. However, future studies can build upon the results of this coaching case-study, with detailed behaviour data, by increasing sample size as well as further discovering the influence of contextual variables, such as athletes' ability and experience level, on athlete learning, quality of experiences, and satisfaction. Additional exploration is also needed, through qualitative methods, to understand coaches' tacit cognitive processes and to learn about the intentions, knowledge and experience that guide their coaching.

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