Heart Rate Recovery (HRR%) Variation by Position and Measurement Time After Imitation Sparring in Male Jiu-Jitsu Trainees with White Belt

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Abstract

This study measured the physiological response caused by the attack and defence of the top and bottom positions in the Jiu-jitsu game with heart rate to investigate the recovery trend between each position using heart rate recovery (%). The subjects of this study were eight white belt men with more than one year of training experience in the adult division of the Jujitsu competition (from 19 to 29 years). Four teams, each consisting of two people, were selected and experimented by cross-allocation. The sparring was performed in three rounds of five minutes, assuming the competition and the rest time was applied the same as the sparring time. Each position's heart rate recovery rate (%) measurement was based on the heart rate level just before each round. The heart rate of thirty seconds, one, two, three, four, and five minutes immediately after each round (sparring) was measured and expressed in %. The results are as follows: First, the heart rate level immediately after sparring between positions showed a high heart rate level in the bottom position immediately after all rounds (sparring). Second, it was found that the bottom position performed exercise under higher physiological conditions than the top position, and the heart rate recovery tended to rapidly decrease in the bottom position at the same rest time. Third, resting heart rate appears to predict heart rate recovery.

Keywords: Jiu-Jitsu, Jiu-Jitsu Position, Jiu-Jitsu Sparring, Heart Rate, Heart Rate Recovery (%)

1.0 Introduction

Jiu-Jitsu, an ancient martial art that originated in Japan and later gained immense popularity in Brazil, is characterized by its ground-based techniques and grappling manoeuvres (Du, 2005). Over the years, it has witnessed an influx of trainees, many starting with a white belt, the first rank in Brazilian Jiu-Jitsu (BJJ) (Hopkins, 2020). Understanding physiological responses during training is essential for optimizing performance and ensuring athlete safety, especially among novices (Robert E Smith et al., 2015). One of the pivotal metrics in gauging cardiovascular and overall health, both at rest and post-exercise, is Heart Rate Recovery (HRR%). Moreover, Brazilian Jiu-jitsu, newly added to the 2018 Asian Games martial arts event, is a world-famous fighting sport (Coswig1ABCDE et al., 2018). The martial arts specialized in ground techniques, joint breaking, and choking instead of kicks and punches (Scoggin III et al., 2014). Technically, Jiu-Jitsu is divided "into two positions: "guard pass fighter (top) and guard play fighter (bottom) according to the body-to-ground body contact (Burke et al., 2007). In each position, attacks and defences are periodically attempted to achieve success with ground occupation and submission techniques such as sweep, guard pass, and mount (Kanthack et al., 2022). Jiu-jitsu is a fighting sport where intermittent movements are crucial, with high, middle and low-intensity movements alternating during the game (Ahmad et al., 2019; Andreato et al., 2013). It is an aerobic exercise with an appropriate glycolysis process (Kanthack et al., 2022). Previous studies have reported that the ratio of Jiu-jitsu technical attempts and rest time is 6:1 or 8:1, which is much higher than other interpersonal fighting sports such as judo (2:1 or 3:1) and wrestling (3:1 ratio) (Andreato et al., 2017). This suggests that the degree of physiological response may be high during Jiu-jitsu. It also means that there may be differences between the two positions depending on the posture and technique used.

Heart rate decreased rapidly for one or two minutes after maximal exercise and decreased slowly after three minutes. During this heart rate recovery reaction, the body resynthesizes energy, replenishes oxygen, removes lactic acid and circulating hormones, and lowers body temperature (Ji et al., 2023; Martinmäki & Rusko, 2008; Ullah et al., 2023).

Healthy and well-trained athletes' heart rate recovery responses are reported to appear quickly after exercise (Yoon, 2022). Moreover, in the early stages of jiu-jitsu, the heart rate increases due to sympathetic nerve activity, catecholamine secretion, and increased muscle temperature (Imai et al., 1994).

In addition, intermittent technical movements of low, medium, and high intensity increase the oxygen demand of skeletal muscles, leading to maximum heart rate

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(HRmax) levels. This cardiovascular response is controlled by transmitting afferent information from various body mechanics and chemoreceptors to the cardiovascular centre of the medulla oblongata, starting from the upper cerebral centre (Mehdi & Ali, 2023; Powers et al., 2021). On the contrary, the recovery response of the elevated heart rate after Jiu-jitsu is due to the cessation of afferent signals of the cardiac mechanic receptors and the muscle mechanical (Group III) and chemical (Group IV) receptors due to the decrease in oxygen demand, and the activation of parasympathetic nerves and suppression of the sympathetic nerves.

Based on the results of previous studies, it can be predicted that Jiu-jitsu players with a fast recovery rate of heart rate are more likely to show good athletic performance in the next competition than those who do not. As a result, examining the heart rate recovery of Jiu-jitsu players helps forecast the aerobic capacity and exercise performance of athletes in Jiu-jitsu competitions. Previous studies on the number of Jiu-jitsu are currently actively conducted concerning physiological variables, technical analysis, and injury mechanisms (Powers et al., 2021; Tarigan et al., 2023).

However, there has yet to be a study to compare the recovery trends by the top and bottom postures by measuring the physiological response to attack and defence of techniques during a Jiu-jitsu match by heart rate. In line with this, the study aimed at measuring the physiological response caused by the attack and defence of the top and bottom positions in the Jiu-jitsu game with heart rate to investigate the recovery trend between each position using heart rate recovery (%) (Bergfeld et al., 2019).

Heart Rate Recovery (HRR%) represents the rate at which an individual's heart rate returns to baseline after strenuous activity (Daanen et al., 2012). A delayed HRR predicts mortality and a marker of autonomic nervous system dysfunction (Jouven et al., 2005). Although the significance of HRR% is well-acknowledged in traditional sports, its implication in martial arts, specifically in the context of Jiu-Jitsu and its variation by position during sparring, remains under-explored (Jolly et al., 2011).

Most studies focusing on HRR% have historically revolved around mainstream sports such as running, swimming, or cycling (Arena et al., 2007). However, combat sports, particularly BJJ, involve complex movements and tactical decision-making under physical duress, which may uniquely influence HRR (Costa, 2012). Another dimension that needs more comprehensive research is the role of the specific position assumed during sparring in BJJ. Imitation sparring, a controlled practice method among white belt trainees, can vary significantly in intensity and physiological demand based on the position (guard, mount, side control, etc.) (Ribeiro et al., 2018). Consequently, this suggests that HRR% might display position-specific variation, although empirical data on this premise is scanty. Furthermore, while it is customary to measure HRR% immediately after exercise, the optimal timing for measurement in the context of BJJ remains ambiguous. Earlier studies in other sports advocate for the 1-minute post-exercise mark as a standard (Peçanha et al., 2017), yet given the unique demands of BJJ, this might not capture the complete picture.

Therefore, the current research endeavours to bridge these knowledge gaps by evaluating the variation of HRR% by position and measuring time after imitation sparring in male Jiu-Jitsu trainees with a white belt. The study hopes to contribute valuable insights for trainers and practitioners alike in optimizing training regimens and understanding cardiovascular responses in this intricate martial art.

2.0 Literature review

'Jiu-Jitsu', which has been adopted as an official event since the 2018 Jakarta Asian Games, is currently gaining popularity around the world, and the number of Jiu-Jitsu practitioners is gradually increasing in Korea. Accordingly, many experimental studies on Jiu-Jitsu are also increasing, but research still needs to be expanded in Korea (JCCN Filho & Neto, 2020). Naturally, much research is done in Jiu-Jitsu, where players are subdivided according to age, weight class, gender, belt, etc. various factors such as competition time, skill preference, and competition propensity exist according to the belt, and it is considered necessary (Sousa et al., 2020).

In a previous study, Andreato et al. (2013) conducted four 10-minute games with ten players (Black Belt, Brown Belt) to analyze the physiological responses of Jiu-Jitsu players. They studied energy metabolism, hormones, cell damage, and heart rate responses. Heart rate was analyzed before and after the match, and although there was no difference during the simulated match, it was explained that the first match showed high adrenaline activity (Levick, 2000). Another study on the physiological response of Jiu-Jitsu players to sparring is Øvretveit (2018) reported the average heart rate during sparring by conducting six-minute sparring five times in a row with a 90-second break for 12 male athletes with 4.6 ± 2.2 career (Øvretveit, 2018). The study measured the cardiovascular response of 54 Jiu-Jitsu athletes to modified burpee test training (Siska & Brodani, 2017). In this way, it is thought that studying the athletes'

physiological response by imitating the actual game can be used as valuable data for the design of a Jiu-jitsu training program or the athlete's performance (Morshedi-Meibodi et al., 2002). Among these, heart rate is considered a factor that must be studied in jiu-jitsu, known as aerobic exercise involving intermittent glycolysis (Abdullah et al., 2016; Andreato et al., 2017).

As Jiu-jitsu research continues, studies focusing on detailed factors are also increasing, such as the autonomic control of the heart according to the jiu-jitsu game style (guard play, guard pass). Rossi et al. (2022) reported similar physiological and perceptual responses between winners and losers in a Jiu-jitsu imitation match. In addition, we compared physiological variables between Jiu-Jitsu and Nogi Jiu-Jitsu and found similar heart rate responses.

As such, various Jiu-jitsu studies are being conducted, but most studies involving heart rate have been conducted by measuring heart rate before, after, or during the game (Du, 2005). However, few studies have observed the recovery response of heart rate during the rest period from immediately after the game (El Agaty et al., 2017).

Jiu-jitsu competitions are held as tournaments. We noted that rapid heart rate recovery after a match can be applied positively to the next match, and we thought it would be meaningful to study heart rate recovery response during rest periods in detail (Borresen & Lambert, 2008). In addition, in several studies, experiments were conducted by mixing players of various belts. However, we predicted that there would be deviations in physical strength and physiological responses according to Jiu-jitsu belts (Freeman et al., 2006). Therefore, to minimize this deviation, we conducted the study with subjects of the same level (belt) as much as possible. We divided the subjects' postures during the Jiu-jitsu competition into a bottom position in which the hip or back is in contact with the floor and a top position in which the hip or back is not in contact with the floor (Jones & Ledford, 2012).

We predicted that the heart rate recovery response would differ between those who spent much time in a lying or sitting position during the game and those who spent much time in a standing position. Not many Jiu-jitsu studies were conducted by dividing these two positions. It was worth researching because almost all Jiu-jitsu competition situations are divided into top and bottom positions. The significance of Heart Rate Recovery (HRR%) as an indicator of cardiovascular health and fitness has been well-established in the scientific community. Its value is recognized as a post-exercise physiological response and a potential predictor of cardiovascular-related mortality (Scott et al., 2016; Shetler et al., 2001). (Anderson et al., 2020) emphasized its predictive utility, associating delayed HRR with increased mortality risks, suggesting its potential as a health surveillance tool. Traditional sports, ranging from running and swimming to cycling, have been at the forefront of HRR% studies.

Arena et al. (2007) found that the HRR% was quicker in aerobic sports, implying better cardiovascular health and efficient autonomic function among athletes. However, while these sports involve consistent physical demands, combat sports introduce a different dynamic. The sporadic and explosive nature of movements and the strategic elements make combat sports like Jiu-Jitsu a unique realm for HRR% investigation. Though gaining in popularity, Brazilian Jiu-Jitsu (BJJ) needs more representation in cardiovascular research. Costa (2012) provided one of the first deep dives into the cardiovascular demands of BJJ. Their findings highlighted that, given the unique physiological demands, the cardiovascular responses in BJJ were distinct from other sports. This underpins the need to explore HRR% specifically within the BJJ context.

One of the fundamental aspects of BJJ, especially for novice trainees or white belts, is the practice of imitation sparring. As described by Ribeiro et al. (2018), imitation sparring, despite its controlled nature, has a varied intensity depending on the BJJ position – guard, mount, or side control. However, the research literature has not definitively concluded how these positions impact HRR%. Another intriguing facet is the optimal timing for HRR% measurement post-exercise.Peçanha et al. (2017) advocated the 1-minute post-exercise mark as a standardized measure in conventional sports.

Nevertheless, as Robert E Smith et al. (2015) noted, BJJ's intensity and varied nature might necessitate different time intervals to understand HRR comprehensively. The heart's ability to recover after exercise reflects an individual's cardiovascular fitness and provides insights into the autonomic nervous system's balance and function. One aspect that the existing literature has repeatedly highlighted is the relationship between HRR and autonomic function. A slower HRR is often linked with diminished parasympathetic reactivation post-exercise, signalling potential autonomic dysfunction (Galiuto et al., 2018).

3. Research method

3.1 Research Design

Three rounds of sparring were held for each team, assuming a tournament match. Based on the rulebook of the international Brazilian Jiu-Jitsu Federation. Sparing was conducted for five minutes, which is the duration of

the white belt competition, and the break time was also set to five minutes according to the rulebook. During sparring, subjects in each position were controlled to exert maximum effort for skill success. Moreover, when the players were worn out and limited movement, they were induced to perform the exercise with the utmost intensity while being urged to minimize the fixation state as much as possible. In addition, since it is sparring assuming an actual match, the position changes as the match progresses. Still, two pre-selected measurers recorded the occupancy time for each player's position and classified the subjects into the top and bottom positions according to the occupancy time. The experimental (sparring) process is shown in Figure 1.

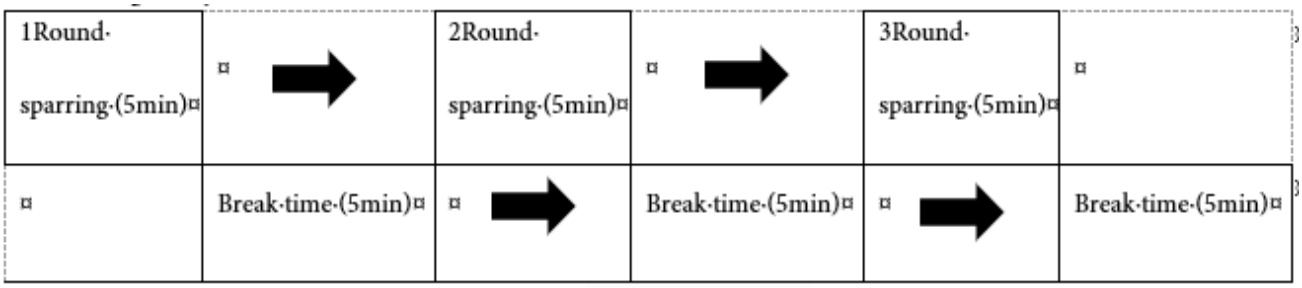

Figure 1. Experimental process

Table 1

Demographic Information

Team	Respondent(N=8)	Age(years)	Career(years)
1	A	28.6	1.8
	B	27.4	1.2
2	C	26.8	1.7
	D	23.2	1.4
3	E	23.8	1.5
	F	20.6	1.3
4	G	20.2	1.3
	H	27.5	1.5
		24.8±3.3	1.5±0.2

Source: authors estimation

Table 1 shows women's and men's competitions in Jiu-Jitsu, which are held according to age, weight class and belt level. This study selected white-belt-level men with more than one year of training experience who participated in the Jiu-Jitsu competition (Adults: 19 years to less than 29 years) as subjects. The characteristics of the subjects are shown in Table 1.

3.2 Sample Size

The useable sample size for the present study is n=08, and the utilization of a small sample size, as seen with the eight participants in this study, is not uncommon in specialized research settings.

Peduzzi et al. (1996) suggest that small sample sizes can be justified in pilot or exploratory studies, especially when examining a niche population or when the study is a precursor to a more extensive, more comprehensive study. Furthermore, specialized populations, such as white-belt-level male trainees in Jiu-Jitsu, might be limited in number, mainly when specific criteria are set for participant selection. Dumas-Mallet et al. (2017) affirm that smaller sample sizes are often seen in exploratory studies where the primary goal is to identify trends or generate hypotheses rather than to validate a phenomenon. Uniformity of Experience: By focusing on participants with approximately one year of experience, the study aimed to minimize variability in skill level and ensure that participants understood Jiu-Jitsu techniques and practices. This decision aligns with findings from Smith and Lilienfeld (2015), who emphasized the importance of homogeneity in skill level when analyzing physiological responses to reduce confounding variables.

3.3 Research Instrument

A pilot experiment attempted to monitor heart rate using a measuring device. However, there was a drawback in that it took more work to fix the measuring device throughout the intense, high-intensity sparring process. Therefore, two heart rate measures were selected, and sufficient education and practice were controlled for two weeks. The same person assessed the heart rate throughout the trial to ensure consistency. At each measurement time, the measurer lightly put the index and middle fingers on the individuals' carotid arteries, measured it for ten seconds, multiplied it by six, and recorded the heart rate. The timing of heart rate measurement is shown in Figure 2.

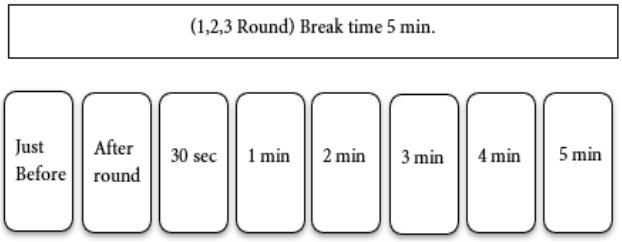

Figure 2: Heart rate measurement period

3.4 Data Analysis Techniques

The heart rate at each location was measured seven times (immediately after sparring, thirty seconds, one, two, three, four, five minutes) during a five-minute rest period immediately after each round, and the mean and standard deviation were calculated. Based on this, the significance level by location and period was investigated using the SPSS 22.0 statistical program Two-way Repeated Measurement ANOVA. The post-comparison method was used to confirm the interaction between the variables showing a significant difference, and the significance level was set to .05. Also, the heart rate recovery (%) was measured based on the heart rate immediately before each round. However, the heart rate recovery (%) was used only to explain the level of heart rate recovery for each period, and analysis through statistical programs was not performed.

4.0 Results and Discussion

Results of the study revealed that Tables 2, 4 and 6 show the two-way ANOVA and post-comparison results of the change in recovery rate of heart rate by position according to the rest time measurement period after rounds first, second, and third, and Figure 3, 5 and 7 show graphs of recovery rate of heart rate for each round position. The heart rate of the first and second rounds was high in the bottom position from the sparring immediately to the five minutes (p<.05 p<.043).

However, the third round heart rate was higher in the top position immediately after sparring but lower in the bottom from thirty seconds to five minutes. However, there was no significant difference between positions.

Table 2

(Round 1) HRR (%) changes by position according to the rest time measurement period. Two-way ANOVA

	M±SD										
Position	**①1R Before**	**②1R After**	**③ 30 sec**	**④ 1 min**	**⑤ 2 min**	**⑥ 3 min**	**⑦ 4 min**	**❽ 5 min**		**F**	**P**
Ⓣ	70.25	178.5	156.0	142.5	127.5	123.0	118.5	115.5			
	±16.68	±7.55	±10.95	±5.74	±11.35	±7.74	±9.00	±5.74			
HRR%	100%	254%	222%	202%	181%	175%	168%	164%	Time	59.835***	.000
	76.25	190.5	153.0	135.0	118.5	112.5	99.0	93.0			
Ⓑ	±6.55+	±20.42+	±11.48+	±7.74+	±19.82+	±23.17+	±15.87+	±15.87+	time ×	2.361	.05
HRR%	100%	283%	227%	201%	176%	167%	147%	138%	position		

*p<.05, ***p<.001

Ⓣ Top position, Ⓑ Bottom position, ① just before IR, ② immediately after IR, ③ 30 seconds, ④ 1 minute, ⑤ 2 minutes, ⑥ 3 minutes, ⑦ 4 minutes, ❽ 5 minutes

Contrast Ⓣ Top position ①=②>③>④>⑤>⑥>⑦>❽ Ⓑ Bottom position ①=②>③>④>⑤>⑥>⑦>❽

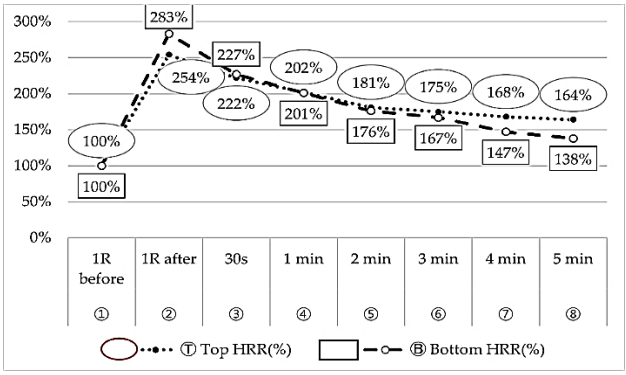

Figure 3: HRR% (Heart Rate Recovery) in the first round

In the first round, the heart rate decreased significantly from the sparring immediately to the five min as the break time increased (p<.000***). The bottom position showed a lower heart rate up to thirty seconds, one, two, three, four, and five minutes compared to the top. In addition, heart rate in each position decreased significantly to thirty-second, one, and two min (p<.006**, p<.006**, p<.004**), and two, three and four min were gradually decreased at the level of no significant difference. Four minutes and five min were significantly decreased (p<.002**). In addition, the rate of heart rate increase (%) immediately after Round one was higher in the bottom position (283%) than in the top position (254%). Heart rate recovery (%) was similarly reduced from immediately after sparring to three min, and the three-minute to five-minute break time showed a high recovery rate in the bottom position.

Table 3

(Round 2) HRR (%) change by position according to rest time measurement period Two-way ANOVA

	M±SD										
Position	① **2R Before**	② **2R After**	③ **30 sec**	④ **1 min**	⑤ **2 min**	⑥ **3 min**	⑦ **4 min**	❽ **5 min**		**F**	**P**
Ⓣ	115.5	180.5	154.5	142.5	124.5	117.0	114.0	111.0			
	±5.74	±8.84	±11.36	±9.00	±9.00	±10.39	±6.93	±6.00			
HRR%	100%	156%	133%	123%	108%	101%	99%	95%	Time	107.892***	.000
	93.0	183.0	151.5	132.0	112.5	99.0	97.5	87.0			
Ⓑ	±15.87	±7.75	±21.56	±10.95	±7.55	±3.46	±14.18	±10.39	Position ×	2.452	0.43
HRR%	100%	197%	163%	142%	106%	106%	105%	94%	Time		

*p<.05, ***p<.001

Ⓣ Top position, Ⓑ Bottom position, ① just before IR, ② immediately after IR, ③ 30 seconds, ④ 1 minute, ⑤ 2 minutes, ⑥ 3 minutes, ⑦ 4 minutes, ❽ 5 minutes

Contrast Ⓣ Top position ①=②>③>④>⑤>⑥>⑦>❽ Ⓑ Bottom position ①=②>③>④>⑤>⑥>⑦>❽

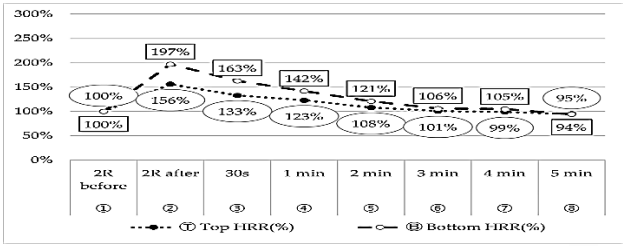

Figure 4: HRR% (Heart Rate Recovery) in the second round

In the second round, the heart rate decreased significantly from the sparring immediately to the five min as the break time increased (p<.000***). The heart rate of the bottom position was lower in thirty seconds, one, two, three, four, and five minutes compared to the top position. In addition, heart rate in each position decreased significantly to thirty-second one min, two min, and three min (p<.003**, p<.022*, p<.000***, p<.001**) and gradually decreased at the level of no significant difference in three min and four min, and significantly decreased in four min and five min (p<.017*). In addition, the rate of heart rate increase (%) immediately after Round two was higher in the bottom position (197%) than in the top position (156%). The heart rate recovery rate (%) was higher for the bottom position during the five-minute break than for the top.

Table 4

(Round 3) HRR (%) change by position according to rest time measurement period Two-way ANOVA

	M±SD										
Position	① **3R Before**	② **3R After**	③ **30 sec**	④ **1 min**	⑤ **2 min**	⑥ **3 min**	⑦ **4 min**	❽ **5 min**		**F**	**P**
Ⓣ	111.0	177.0	150.0	142.5	120.0	111.0	108.0	102.0			
	±6.00	±11.49	±10.95	±9.00	±8.48	±3.46	±4.90	±4.90			
HRR%	100%	159%	135%	128%	108%	100%	97%	92%	Time	120.976***	.000
	87.0	175.5	145.5	130.5	100.5	91.5	85.5	79.5			
Ⓑ	±10.39	±5.74	±11.36	±13.30	±9.00	±10.25	±13.30	±18.57	Position ×	2.286	0.57
HRR%	100%	202%	167%	150%	115%	105%	98%	91%	Time		

*p<.05, ***p<.001

Ⓣ Top position, Ⓑ Bottom position, ① just before IR, ② immediately after IR, ③ 30 seconds, ④ 1 minute, ⑤ 2 minutes, ⑥ 3 minutes, ⑦ 4 minutes, ❽ 5 minutes

Contrast Ⓣ Top position ①=②>③>④>⑤>⑥>⑦>❽ Ⓑ Bottom position ①=②>③>④>⑤>⑥>⑦>❽

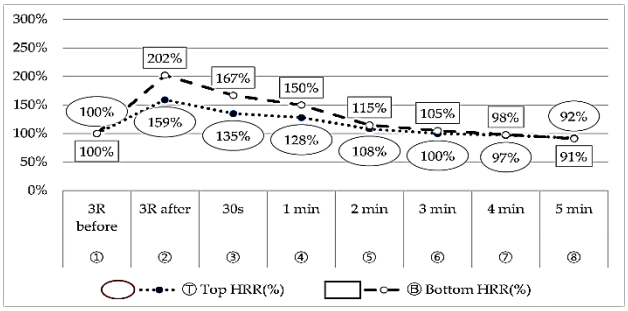

Figure 5: HRR% (Heart Rate Recovery) in the third round

In the third round, the heart rate decreased significantly from the sparring immediately to the five min as the break time increased (p<.000***). The heart rate was low in the bottom position immediately after sparring and thirty seconds, one, two, three, four, and five minutes, but there was no significant difference between positions. In addition, the rate of heart rate increase (%) immediately after Round three was higher in the bottom position (202%) than in the top position (159%). The heart rate recovery (%) was similar after four min, with the bottom position having a higher recovery rate of up to four min than the top position.

4.1 Discussion

In Jiu-Jitsu sparring, it is advantageous for the bottom position to try the technique while holding the opponent's gi or body part. At the same time, the top position needs to try the technique without holding the gi or body part. For this reason, in the bottom position, static muscle contraction using the upper extremity muscles to control the opponent's movement when attempting the technique is relatively more than dynamic muscle contraction. In contrast, dynamic muscle contraction attempts will increase in the top position due to the technical characteristics between positions. The bottom position uses the upper extremities with relatively less muscle mass (Bompa & Buzzichelli, 2019).

In previous studies on muscle contraction and one stroke volume, it was found that the activity of the sympathetic nerve increases according to the utilization of muscle mass during isometric exercise and that stroke volume during upper extremity exercise is relatively dependent on skeletal muscle (muscle pump) (Seals, 1989). In addition, it has been reported that the blood flow to the heart is lower than that of lower extremity exercise (Miles D, 1989). This study also suggests that increasing the exercise intensity can increase the heart rate compared to lower extremity exercise. In addition, Previous studies on posture and heart rate reported that the heart rate was higher in standing than in lying posture (Bompa et al., 2019; Shamsuzzaman et al., 1998). In the upright posture, lower extremity exercise increased the vein blood flow through the femoral vein, while the vein blood flow decreased when the exercise was stopped. Therefore, it is thought that the heart rate change in the top position, in which the movement of the lower limb is relatively high, is more frequent than in the bottom position. However, when attempting a technique using the upper extremities and lower extremities in the top position, the technique failure due to the technique attempt in the bottom position would have stopped or reduced the movement caused by muscle contraction of the lower extremities, so it is thought that a continuous increase in heart rate would not have been possible. As a result, it is judged that the first and second-round heart rate levels were higher in the bottom position. However, the third-round heart rate did not show a significant difference between positions but was slightly higher in the top position.

This result is because fatigue was accumulated due to the preceding sparring, the time to maintain a static posture at each position increased compared to the first and second rounds, and the active technique attempts during the third round sparring were relatively decreased. Also, the physiological characteristics of high heart rate and low stroke volume in the upright position were relatively dominant in the top position, suggesting that the heart rate immediately after the third round was high. Heart rate recovery (HRR%) refers to the rate at which the heart rate decreases after exercise and reflects autonomic nervous system function (Peçanha et al., 2017).

The heart rate recovery (HRR%) during the first round rest period shown in the results of this study was based on the heart rate just before the first round (100%). In the top position immediately after sparring (254%), thirty sec (222%), one min (202%), two min (181%), three min (175%), four min (168%), five min (164%), immediately after sparring (283%), thirty sec (227%), one min (201%), two min (176%), three min (167%), four min (147%), and five min (138%) were shown. From immediately after sparring to three minutes, It decreased similarly. The decrease in the bottom position was high at three and five min of rest time.

The heart rate recovery (%) during the second round rest period is based on the heart rate level (100%) just before the second round. In the top position, immediately after sparring (156%), thirty sec (133%), one minute (123%), two min (108%), three min (101%), four min (99%), five min (95%), in the bottom position immediately after sparring (197%), thirty sec (163%), one min (142%), two min (121%), three min (106%), four min (105%), and five min (94%) showed heart rate recovery. It showed a rapidly decreasing pattern in the bottom position. During the

third round rest period, the recovery is based on the heart rate level (100%) just before the third round. In the top position, immediately after sparring (159%), thirty sec (135%), one min (128%), two min (108%), three min (100%), four min (97%), five min (92%), in the bottom position immediately after sparring (202%), thirty sec (167%), one min (150%), two min (115%), three min (105%), four min (98%), and five min (91%) showed a heart rate recovery rate, which decreased to 4min. It showed a similar heart rate recovery level after four min.

These results show that the initial heart rate recovery immediately after exercise is determined by exponential decay and parasympathetic response of the heart (Freeman et al., 2006), and the effect of this activation is most substantial during the first thirty seconds after exercise Peçanha et al. (2017) seem to be consistent with previous studies. In addition, a low resting heart rate in a bottom position means a higher parasympathetic nerve activity or a lower sympathetic nerve activity. It is thought that this may explain the rapid recovery of heart rate, although the heart rate level immediately after it was high in the lower positions. After that, it is judged that the tendency of the heart rate to decrease as the resting time increases is a slow form (Sousa et al., 2020; Yoon, 2022) due to the sum of the parasympathetic response and the decrease in sympathetic activity. In addition, according to the study results of Levick (2000), athletes with high parasympathetic nerve activity and low sympathetic nerve activity were more effective than non-athletes. Compared to that, it reported that the resting heart rate was lower and the heart rate recovery rate was faster, so it is judged that this study can support the results of this study, in which the resting heart rate was rapidly reduced to the rest level immediately after sparring in the lower bottom position. Therefore, heart rate after high-intensity jujitsu sparring showed different tendencies for each position during rest time; as rest time increased, it showed rapid recovery in the lower position. The heart rate recovery (%) tended to decrease faster at the same rest time in the bottom position than at the top as the rest time increased in all rounds. This suggests that a relatively low pre-round heart rate level is essential for recovery during rest periods, and a lower heart rate right before may lead to a faster recovery.

5.0 Practical Implications

Recognizing that the bottom position often leads to higher heart rates in the initial and subsequent rounds can guide trainers in structuring training sessions. For instance, integrating periodic breaks or alternating between top and bottom positions might aid in maximizing stamina and overall performance. Given the rapid initial recovery noted, especially in the bottom position, trainers could devise specialized recovery routines. Techniques such as targeted stretching, controlled breathing exercises, and progressive muscle relaxation can be introduced to capitalize on this rapid recovery phase and further enhance parasympathetic activation.

Athletes can use the knowledge of differential HRR to strategize during competitive sparring. Suppose an athlete knows his opponent frequently adopts the bottom position and might exhibit a higher heart rate. In that case, they can leverage this to push the pace, potentially fatiguing the opponent quicker.

6.0 Conclusion and Recommendations

In this study, immediately after high-intensity jiu-jitsu sparring, the exercise intensity level performed by the heart rate displayed at each position was identified for each round. It was found that the lower position performed exercise under higher physiological conditions than the upper position, and the trend of heart rate recovery during the rest period according to the round progress was also identified. However, due to the small number of subjects in this study, it may be limited to objectifying the results. Therefore, proceeding with more subjects in the follow-up study is necessary. In addition, additional research on the physiological mechanisms and exercise performance according to belt level, weight class and gender can be positive for jiu-jitsu performance improvement and training programs.

Heart Rate Recovery (HRR%) Variation by Position and Measurement Time After Imitation Sparring in Male Jiu-Jitsu Trainees with White Belt" provides an illuminating exploration into the intricate physiological demands of Jiu-Jitsu sparring. The unique aspects of both top and bottom positions in Jiu-Jitsu, each with its characteristic techniques and muscular requirements, shed significant light on the differential heart rate responses and recovery trajectories. Our investigation shows that the bottom position, characterized by more static muscle contractions, demonstrated higher heart rate levels during the initial and subsequent rounds of sparring. However, the distinction between the two positions became less pronounced by the third round, indicating factors like accumulated fatigue and a general decrease in active technique attempts. Furthermore, the heart rate recovery (HRR%) trends surfaced as a pivotal metric in gauging the autonomic nervous system's efficiency and adaptability post-exercise. Notably, the bottom position exhibited a more rapid initial recovery, potentially stemming from heightened

parasympathetic activity or a subdued sympathetic response. This observation aligns with existing research, underscoring the importance of the parasympathetic response in rapid post-exercise recovery.

7.0 Limitations and Future Research

This study has the following limitations and directions for future research. The data for the present study was collected from n=8 respondents, which is one of the limitations of the present study. Therefore, future researchers may collect data from the enormous samples for better results and better generalization of the findings. The mixed-method approach was beyond the scope of the current study because of time constraints, but future researchers may use a mixed-method study. Due to time constraints, the data for the present study were collected based on cross-section data; therefore, future research may conduct longitudinal studies to understand phenomena better

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