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RESEARCH ARTICLE

Effect of Embedded the Post-Training Recovery Services following Resistance Training on Muscular Strength in Vietnamese National Para Powerlifting Athletes – A Case Study

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Abstract
Purpose: The aim of this study was to assess and compare the muscular strength with bench press test and dominant hand-grip test between pre-intervention and post-intervention. Methods: Two male para powerlifting athletes from Vietnam National Team were recruited and volunteered to participate in this study. The intervention scheme of this study consisted of resistance training program specially designed for the para powerlifting athletes were carried out for a duration of 8 weeks, three times a week, training load was set from 65% to 85% of the 1 Repetation Maximum of the participants, repetition and set of training was from 8 reps/3 sets to 10 reps/6 sets. The embedded post-training recovery services consisted of sport massage sessions, sauna bathing, High Intensity Laser Therapy and Kinesio taping. Results of current study revealed that significant improvement of Bench Press and Hand-Grip strength tests between pre-intervention and post-intervention ($p<0.05$). Conclusions: The para elite athletes from Vietnam, in the case of the elite sporting environment where small changes in their performance often represent a meaningful difference for performance outcomes, informed decisions surrounding the context of post-training recovery services is of utmost importance.

Keywords
Resistance Training, Post-Training Recovery Services, Para Powerlifting Athletes

INTRODUCTION

Paralympic powerlifting (PP) is a sport that requires muscular strength and the only discipline is adapted bench press, so the sport is practiced by men and women with physical disabilities in the lower extremities. The sport attracted many participants; Therefore, it is becoming increasingly important to monitor athletes' preparations in order to optimize results in competitions. In this sense, to maximize performance, PP training involves the manipulation of various biodynamic variables such as volume, intensity, frequency and intensity, among others (De Almeida Paz et al., 2020; Santos et al., 2018). It is well documented that resistance training (RT) is an optimal training method for improving muscle strength and impulse-related performance. Considering the importance of strength for powerlifters during daily training and competition, designing RT programs for powerlifters requires various aspects such as exercise selection, exercise order, training frequency, training load, number of repetitions,

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and rest interval between sets to achieve greater efficiency.

Also, the sport of para powerlifting by identity combined with the training in general demand footsteps for improved performance in competition and to maintain quality of life for the athletes (**Gardner & Pierce, 2015**). Due the high demands in training, there is higher incidence of chronic injury from overuse and imbalances from wheelchair and/or crutch use for daily activity (**Tuakli-Wosornu et al., 2018**). Injuries of this nature directly inhibit day-to-day activity for para athletes by expanding difficulty of simple tasks in everyday life (**Tuakli-Wosornu et al., 2018**). Additionally, with concern to the highest level of competition (**Webborn & Van de Vliet, 2012**), the para athletes experience even higher intensity stresses than able-bodied bench press athletes. This is evidenced by the difference in world record performances in most weight classes **(Gérard & their, 2017**). This is also give an idea of regardless of drug testing obligations for the athletes in the all-time open bench press world records. Three of these open classification records are held by para athletes in the IPC (**Gérard & their, 2017**).

Correspondingly of these increased stresses on para athletes, injuries are frequent and also correlated to total volume loads related to their daily movement mechanics. From the epidemiological study reported regarding injuries from the 2012 London Paralympic games revealed that the most commonly injured area was the shoulder followed by the chest and then the elbow (**Lockie, Callaghan, Orjalo, & Moreno, 2018**). The trend of soft tissue chronic injuries to the shoulder region of crutch and wheelchair dependent from the para athletes have been consistently observed for decades (Lockie et al., 2018). Able-bodied powerlifters without the chronic and repetitive overuse issues by para athletes are also shown to have shoulder imbalances making it reasonable to accept that bench press training and constant crutch/wheelchair use compound these issues for para athletes (**Król & Gołaś, 2017**). The accumulation of fatigue from the combination of volume loads of daily locomotion stress outside of training and bench press training can quickly marshal to overtraining phenomena (**Armstrong, Bergeron, Lee, Mershon, & Armstrong, 2022**).

Nevertheless, bench press is the only required discipline in para powerlifting competition, in which athletes lower the bar to their chest, stops on the chest and then press it upwards to arms-length with locked elbows (**Gołaś et al., 2017**). Athletes will have 3 attempts in an event, and the winner is the one who has the highest lift attempt weights completed in correct positions and sequences as required (**Ferland & Comtois, 2019**). At such, para athletes and are at high possibility for tragic injuries due to fatigue of training and lifting maximal weights during competition. Hence, it is crucial to have well-designed and adaptive resistance training plans for these athletes to look after the quality of life and maximize their performance in competition. Muscle imbalances of the shoulder are a major issue in para athletes. when they have chronic impingement or overuse injuries. they show comparative weakness (**Wang & Cochrane, 2001**). Weakness and fatigue are strong factors in the likelihood of an injury and should be monitored for injury prevention and long-term development of the athlete **(Dugan & Frontera, 2000**). Previous research also points out the increased prevalence of a once-rare injury to the pectoralis major due to the increased competition demands of para weightlifting, in particular the bench press (**Vrcić, Kovačević, Čaušević, Hodžić, & Abazović, 2018**).

In the sport arena, the general adaptation syndrome (GAS) model of stress, recovery and adaptation over time provides a framework for discovering and anticipating fatigue and performance directions in training (**Kiely, 2012**). Also, GAS is widely considered as the basis for modern periodization in training **(Cunanan et al., 2018)**. The importance of recovery is critical to the success or failure of any athlete (**Yılmaz & Tugrul, 2012**). Augmenting adaptation from stressors is vital in performance and athletes, coaches, and sport scientists have used monitoring methods to optimize adaptation with the fitness-fatigue paradigm theory in mind. Also, every athlete responds individually to any training stimulus and programming largely due to their own genetic variations and experience levels in sport (**Huygens, Thomis, Peeters, Vlietinck, & Beunen, 2004**). On top of that, training fatigue also largely influences athletes individually **(Pyne, Mujika, & Reilly, 2009**), these variables combined with the individuality of every athlete creates the need for individual monitoring during the training process. Previous study reported that

consistently drawn to resistance training showing these same fashions of training stimulus and recovery followed by metabolic and neuromuscular adaptations (**Hughes, Ellefsen, & Baar, 2017**). Using this foundation of model in physiological reactions as a guide, with the proper methods the same fashions should be able to be seen in the training of athletes.

In resistance training, strenuous exercise generally develops in significant muscle damage that may affect athletic performance (**Crameri et al., 2007**). Thus, various recovery strategies are often used by athletes as a means to prevent the inflammatory response which go along with the potentially damaging effects of intense exercise. Indeed, most recovery strategies are intended to treat only symptoms of exercise-induced muscle damage by blunting inflammatory responses associated with disturbances to the structural integrity of the exercised musculature (**Minett & Duffield, 2014**). On top of that, be it through lifestyle (e.g. active recovery, sleep), physiological (e.g., post-exercise cooling, massage, compression), or nutritional and pharmacological interventions (e.g. supplements, anti-inflammatory medications), these common recovery techniques aim to hasten regenerative processes below the neuromuscular junction with limited consideration for other causative mechanisms (**Minett & Duffield, 2014**). Nevertheless, the topic of post-exercise recovery from training has been the focus of recent attention in both narrative (Minett & Duffield, 2014). and systematic reviews (**Poppendieck, Faude, Wegmann, & Meyer, 2013**). While these literatures detail the physiological, perceptual, and performance effects during recovery, discussion as to the specificity and context within which interventions are best applied is limited.

Given the significant contributions noted between post-training recovery services on training fatigue and improved performance, further examination of the interaction between these variables was required for further clarification. As such, the primary aim of this study was to assess and compare the muscular strength with bench press test and dominant hand-grip test between pre-intervention and post-intervention. The hypotheses we studied were that: (1) the 8-week of post-training recovery services aid significance improvement of muscular strength on bench press test between pre-intervention and post-intervention; (2) the 8-week of post-training recovery services support significance improvement of muscular strength on dominant hand-grip test between pre-intervention and post-intervention in para power lifter.

MATERIALS AND METHODS

This study was a case study with quasi experimental research, pre-test and post-tests on muscular strength of the participants, the intervention program was carried out one day after the pre-test data collection, and post-data was collected one day after the intervention period. The intervention was the resistance training specially designed for the para powerlifting athletes which consisted of four exercises targeting to strengthen the arm, shoulder and upper back muscles. After each resistance training session, the participants were provided a series of post-training recovery services comprised of sport massage, sauna & Jacuzzi and High Intensity Laser Therapy (HILT) treatments. This study was carried out during general preparation phase of the athletes in their periodization plan.

Participants

Two male para powerlifting athletes from Vietnam National Team were recruited and volunteered to participate in this study (aged 36-38 years, with over 15 years of experience; competing at 49kg and 54kg classes, paraplegia - IPC: F54). Before the trial and after being explained in detail of the study's procedures and risks, the participants and the Para Power Weight Lifting Association of Vietnam have given written consents enables the athletes to participate in the study. The study protocol adhered to the principles of the Declaration of Helsinki and has been obtained approved from the Institutional Review Board of University of Sports Ho Chi Minh City, Vietnam.

Regarding vulnerable groups, the authors took into account the needs and priorities of the groups/individuals in which the study was conducted, in accordance with Articles 19 and 20 of the WMA Declaration of Helsinki, and that the study could not be carried out outside these groups and individuals. In this study, additional measures to protect volunteers were taken into consideration.

Experimental Procedures

All measurements have been carried out in the research laboratory of the Institute of Science and Technology, Hochiminh University of Sports,

Hochiminh City, VIETNAM. Each experimental session started with a standard warm-up consisting of 5 minutes of dynamic stretching and 5 minutes of light lifting. The participants then performed warm-up sets using the exercise of bench press as assessed in the respective session: 5 repetitions, 2 sets with barbell (20 kg), 50% of 1RM and 2 repetitions with 75% of 1RM.

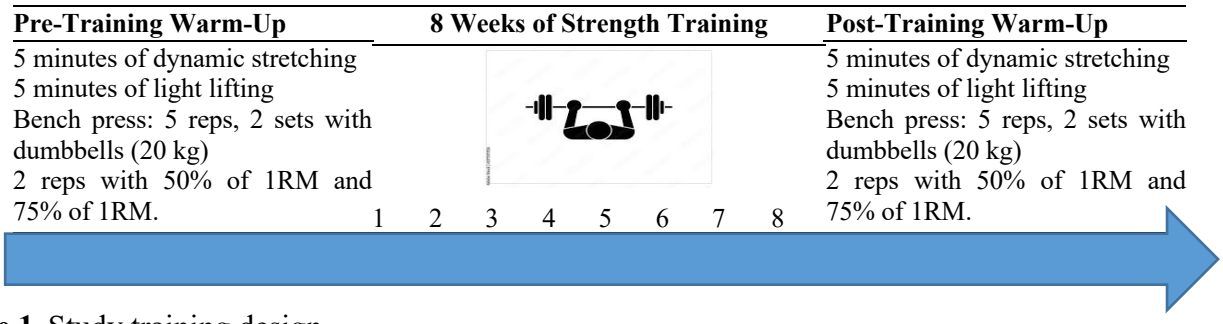

Figure 1. Study training design

Resistance Training Program

Muscular strength is one of the health fitness components. It is referred to as the amount of force production in a single maximal effort (**Kenny, Wilmore, & Costil, 2015**). Inclusion of resistance training in the training program helps to improve muscular strength. It has also been part of the training program for sports that require strength in performing their games.

The intervention scheme of this study consisted of resistance training program specially designed for the para powerlifting athletes were carried out for a duration of 8 weeks, three times a week (Mondays, Wednesdays, and Fridays). Training load was set from 65% to 85% of the 1RM of the participants, repetition and set of training was from 8 reps/3 sets to 10 reps/6 sets as stated in table 1. The resistance training program was designed based of the principle of FITT to Develop Maximum Strength, Power and Hypertrophy (**Teo, 2015**) on the shoulder, chest and arms muscles.

Table 1. Resistance training program

Week	Day	Resistance Training Program			
		Left Bicep Curls (Dumbbell)	Right Bicep Curls (Dumbbell)	Seated Row (Machine)	Lat. Pulldown (Machine)
1	Monday	60% of 1RM (10 reps/6 sets)			
	Wednesday	65% of 1RM (8 reps/6 sets)			
	Friday	70% of 1RM (6 reps/6 sets)			
2	Monday	70% of 1RM (8 reps/4 sets)			
	Wednesday	75% of 1RM (6 reps/4 sets)			
	Friday	80% of 1RM (5 reps/4 sets)			
3	Monday	80% of 1RM (6 reps/3 sets)			
	Wednesday	85% of 1 RM (5 reps/3 sets)			
	Friday	85% of 1 RM (4 reps/3 sets)			
4	Monday	80% of 1 RM (10 reps/3 sets).			
	Wednesday	75% of 1RM (8 reps/3 sets)			
	Friday	80% of 1RM (6 reps/3 sets)			
5	Monday	65% of 1RM (10 reps/5 sets)			
	Wednesday	75% of 1RM (7 reps/5 sets)			
	Friday	85% of 1RM (5 reps/5 sets)			
6	Monday	70% of 1RM (10 reps/5 sets)			
	Wednesday	75% of 1RM (8 reps/5 sets)			
	Friday	85% of 1RM (5 reps/5 sets)			
7	Monday	80% of 1RM (7 reps/6 sets)			
	Wednesday	85% of 1RM (6 reps/4 sets)			
	Friday	90% of 1RM (4 reps/5 sets)			
8	Monday	85% of 1RM (6 reps/5 sets)			
	Wednesday	90% of 1RM (2 reps/5 sets)			
	Friday	100% of 1RM (3 reps/1 set)			

The Post-Training Recovery Services

The embedded post-training recovery services was synchronized with the resistance training program, whereby the volume of resistance training increased from Wednesday to Friday. The athletes practiced 2 sessions a day (morning and evening sessions), of which the main focus training was in the afternoon sessions and supplementary physical exercise was in the morning sessions. Therefore, the embedded post-training recovery services consisted of sport massage sessions were provided by the qualified masseurs on Mondays and Wednesdays after the heavy training sessions for 30 minutes. Additionally, after the heavy training sessions on Fridays, the athletes were scheduled for a holistic full-body post-training recovery services which consisted of combination of sport massage session for 30 minutes, sauna bath for 20 minutes. Also, after the sauna bath session, the participants were treated with the High Intensity Laser Therapy (HILT) for another 20 minutes on the shoulder, chest and upper back muscles. This embedded post-training recovery services with the High intensity laser bio-stimulation with 20W (8101J) for 5 minutes/position, with right and left shoulder muscles, following with High intensity laser for pain relief with 16W (8101J) for another 5 minutes/position on both shoulder muscles and concluded with Kinesio taping (KT) of the shoulder muscles.

The recovery methods embedded in this study because of all these methods targeting on muscles recovery and enhancing performance. Sport massage promoting improved flexibility and range of motion (**American College of Sports Medicine, 2023**), it enhances performance and reduces injury risk (**Journal of Sports Medicine, 2023**). Sauna Bathing promote muscle recovery through increased blood flow and reduced inflammation, accelerating the removal of metabolic waste products like lactic acid (**Laukkanen et al., 2010**). The High-intensity laser therapy (HILT) increases blood flow to the targeted area, enhancing nutrient delivery and waste removal, thereby accelerating tissue repair and reducing inflammation (**Bjerring et al., 2015**). This translates to faster recovery from muscle strains, tendonitis, and other sports-related injuries. Last recovery method is with Kinesio Taping whereby it can support and stabilize joints, reducing pain and proprioceptive deficits, potentially leading to improved athletic performance (**Al-Wadi, 2017**). All the recovery methods are beneficial to recovery and enhancing performance. We considered as post training recovery package.

Measurements

Bench Press

Para powerlifting is a competitive sport which is contested through the bench press event. Bench press test in this study was performed according to the body contact technique (head, upper back and buttocks remain on and touching the bench). During the test session, the participants were able to choose their own grip width recorded with a ruler placed on the barbell. The handle width for the bench press for all the experimental sessions afterwards was kept constant.

This test conducted in accordance with the basic rules of IPC competition bench press include the athlete receiving the weight at arm's length and receiving an audible "Start" command from the head judge once control is established. The athlete then lowers the weight until the barbell contacts the chest for a fully controlled and visible stop. Once a definitive break between the eccentric and concentric movement has been established, the athlete then presses the weight back to arm's-length. An audible "rack" command is then given by the head judge once the athlete has displayed that the bar is under control with elbows locked (**Ferland & Comtois, 2019**).

Handgrip Strength (HGS) Dynamometer Test

The second muscular strength test collected in this study was with the dominant hand-grip strength (HGS) dynamometry test (**Gąsior, Pawłowski, Williams, Marek, & Rameckers, 2018**). This involves using a handheld dynamometer and squeezing with a maximal effort. This results in a force value that can be tracked over time. This method is often used due to the simplicity of protocol and the minimal fatigue that is induced from using such a test (**Twist & Highton, 2013**). A hand dynamometer is an easy way for a coach to track neuromuscular function of an athlete. Jamar dynamometer (Asimo Engineering) had very high inter-ratter reliability and had the highest accuracy of the instruments tested in the study. The hand-held dynamometry is a reliable and valid instrument that is typically used in the clinical setting but has also been shown to useful in monitoring athletes (**Twist & Highton, 2013**).

The testing protocol included being seated with the elbow close to the side of the torso and bent at 90°. These are adaptations from standardized protocols of grip dynamometer testing based on the American Association of hand therapists and Southampton protocols (**Holscher et al., 2011**). HGS test were alternated left then right three times with 30 seconds in between individual tests. In this study, only dominant hand-grip strength tests data were taken into analyses because in general, measurement of HGS is performed with the dominant hand to determine the highest strength value. This is because several studies have observed that HGS is 10% higher with the dominant hand compared with the non-dominant hand (Cornwell, Khodiguian, & Yoo, 2012).

Statistical Analysis

The Shapiro-Wilk test yielded a non-significant p-value of 0.256, further supporting normality. Given the sample size of two, the assumption of normality was considered tenable. Therefore, we employed the paired- samples t-test to compare pre-test and post-test data on strength performance (**Hair et al., 2019**). Mean value and standard deviation for the research parameters were calculated. Paired-samples t-test was employed to compare the significant difference on the mean of muscular strength with bench press and dominant hand-grip strength tests between pre and post-intervention for the two athletes. Significant value was set at $p<0.05$. All statistical analyses were performed using SPSS v.25 (SPSS, Chicago, IL).

RESULTS

A paired-samples t-test was conducted to compare muscular strength with bench press tests between pre-intervention and post-intervention. There was a significant difference in the scores for Pre-intervention (M=148.50, SD=12.02) and post-intervention (M=186.50, SD=16.26); t(1)= -12.67, p = .049, d=2.12. These results suggest that the intervention implemented really does have effect on the muscular strength with bench press test. Specifically, our results suggest that when the intervention carried out, the muscular strength of chest and shoulder muscles improved. Results shown in table 2.

Table 2: Paired-samples t-test of bench press strength test

Test	Pre-Test		Post-Test		t	df	Sig.(2-tailed)
	M	SD	M	SD			
Bench Press Strength	148.50	12.02	186.50	16.26	-12.67	1	.049

To find out is there any significance different on muscular strength with dominant handgrip test between pre-intervention and post-intervention. A paired-samples t-test indicated that scores were significantly higher for the post-intervention scores (M = 55.00, SD = 2.83) than the pre-intervention scores (M = 31.25, SD = .35), t(1) = -13.57, p = .047, d = 9.62. It means the dominant handgrip strength was improved significantly after the intervention as shown in table 3.

Table 3: Paired-samples t-test of dominant hand-grip strength test

Test	Pre-Test		Post-Test		t	df	Sig.(2-tailed)
	M	SD	M	SD			
Dominant Hand Grip Strength	31.25	.35	55.00	2.83	-13.57	1	.047

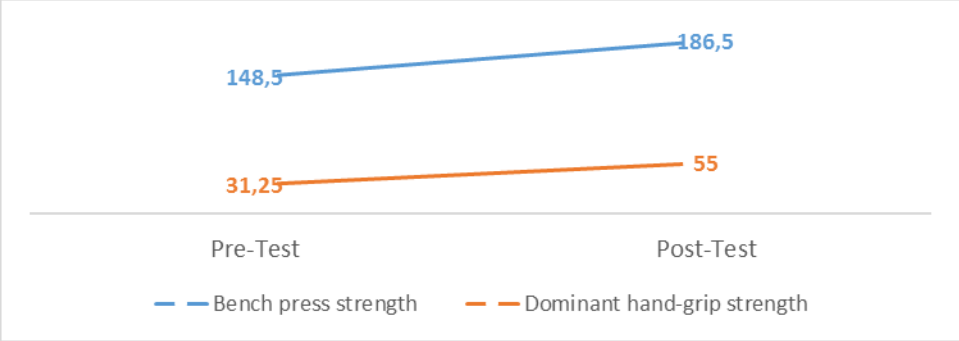

Figure 2. Pre-test and Post-test bench press strength and dominant hand grip strength analysis of the participants

DISCUSSION

Following an intense training session, athletes experience a complex physiological response known as acute exercise-induced muscle damage (EIMD) (**Peake et al., 2015**). This damage manifests as micro-tears in muscle fibers, inflammation, and reduced muscle function (**Prosopol et al., 2020**). By employing these four recovery methods consecutively, athletes can address the various aspects of EIMD and optimize their recovery process. This multi-pronged approach can lead to faster recovery times, reduced muscle soreness, and improved performance in subsequent training sessions. To optimize recovery and promote adaptation to training, a multi-faceted approach incorporating four consecutive recovery methods is often employed. Current study revealed that the embedded intervention program provided after resistance training with the post-training recovery services aid significant improvement in bench press test between pre-intervention and post-intervention t (1) = -13.57, p = .047, d = 9.62. The hypothesis 1 was accepted in this study and this outcome validate that the post-training recovery services are effective to enhance their bench press test performance.

As previous research reported that most commonly injured area for para power weight lifter was the shoulder followed by the chest and then the elbow (**Willick et al., 2015**). The trend of soft tissue chronic injuries to the shoulder region of crutch and wheelchair dependent para athletes has been consistently observed for decades (**Fagher & Lexell, 2014**). Also, para athletes are also shown to have shoulder imbalances making it reasonable to believe bench press training and constant crutch/wheelchair use compound these issues for para athletes (**Melani et al., 2019**). The accumulation of fatigue from the combination of volume loads of daily locomotion stress outside of training and bench press training can quickly lead to overtraining (**Carter, Potter, & Brooks, 2014**). At such, to reduce the shoulder imbalances and fatigue from training and daily locomotion stress outside of training, embedded the post-training recovery services to the para athletes is necessity to reduce fatigue of training and to improved their performance. The results of this study found that the effect size is d=9.62 with huge effect size. Alarge effect size means that a research finding has practical significance and it is shows that the effect is large enough to be meaningful in the real world.

Even though numbers of studies have evaluated the relationships between hand grip strength (HGS) and sport performance, but, when nailing specifically on powerlifting, research on the relationship between handgrip strength and performance is limited. Thus, it is important conduct this study to provide additional information on relationships of HGS in para power lifting. The results of current study showed that dominant hand grip strength were significant difference between pre-intervention (M = 31.25, SD = .35) and post-intervention (M = 55.00, SD = 2.83); t(1) = -13.57, p = .047, d = 9.62. The hypothesis 2 was accepted in this study. The results also reinforce the intervention program provided was effective in assisting the para athletes to improve the strength performance, especially on their dominant hand strength. Current study revealed that the effect size is d=2.14 with large effect size. A large effect size means that a research finding has practical

significance and it is shows that the effect is large enough to be meaningful in the real world.

The results of this study are similar to the previous researchers reported that HGS often been used as an indicator of strength (**Cronin, 2017**). Further, another study reported that a strong correlation between HGS and powerlifting strength. Although many different tests are used to help predict and determine strength; however, as coaches usually find themselves be short of funds and resources, measuring HGS is efficient and accessible (**Schoffstall, Arendt, & Brown, 2013**). Further justification on HGS test was used for this study because powerlifting is concentrated on three fundamental exercises, the back squat (BS), bench press (BP) and deadlift (DL); during each lift, the "power grip" is utilized (**Cronin, 2017**). Previous findings determined this type of grip to be commonly integrated when an individual places a cylindrical-shaped object, like a barbell, in the palm and the fingers form around the object. The hand then serves as the point of contact where forces are transferred, and because of this, HGS is significant for a successful lift (**Cronin, 2017**).

Additionally, powerlifting athletes needed ample HGS. HGS defined as, "the result of the maximum force that the subject is able to exert under normal biokinetic conditions through the voluntary flexion of all finger joints, thumbs, and wrists (**Koley & Yadav, 2009**). As reported that when comparing to other athletic groups, such as gymnasts, powerlifters have shown significantly higher HGS measurements (**Cronin, Lawton, Harris, Kilding, & McMaster, 2017**). Another study found that nearly perfect correlations between HGS and raw powerlifting totals during a meet performance (**Morrison, Schoffstall, Kozlik, & Boswell, 2010**). Current findings are in line with past research reported that hand grip strength can be a predictor and variable of other sport performances in general. Example in combat sports, HGS has been a strong predictor for professional boxers and found to be higher among successful wrestlers (**Nikooie, Cheraghi, & Mohamadipour, 2015**). Current results also in agreement with another research finding that HGS may be a useful tool to predict performance, identify those who possess top performing characteristics and to recruit elite strength athletes. Moreover, it appears that possessing greater HGS may be beneficial to excel in certain sports (**Erdağı, 2020**).

The intervention of post training recovery services provided to the athletes in this study consisted of sport massage, sauna, HILT and tapping after each training session. The outcome of this study verified that the post-training recovery services provided after resistance training is very significant to aid the performance of the athletes in bench press strength and dominant hand-grip strength tests. The first post-training recovery services provided to the athletes during the intervention period was the sport massage by the qualified masseur. Massage is used in general approaches, such as preparation for competition, between competitions and in assisting recovery from training and competition, rather than treatment for specific problem **(Pa, Salamuddin, Zin, & Lian, 2020**).

As reported in literature, sport massage has been used for centuries in an attempt to prevent and cure injuries **(Weerapong, Hume, & Kolt, 2005**). Massage is able to enhance muscle relaxation (**Wiktorsson-Moller, Öberg, Ekstrand, & Gillquist, 1983**), reduce muscle tension and reduce muscle soreness, promote the healing process and consequently, improve athletic performance (**Gasibat & Suwehli, 2017**). Also, Massage as an effective way to prevent acute injuries resulting from abnormal tissue conditions (e.g. muscle tears in tight muscles) and chronic injuries caused by wear and tear (e.g. tendinosis) (**Brumitt, 2008**) by rearranging the muscle fibres. Current results were consistent with the previous findings that sport massage assisting in the muscle strength performance after the services provided.

The current findings also supported that sport massage is able to optimise positive performance factors such as healthy muscles and connective tissues and normal range of motion (**Brumitt, 2008**). With that, preventive massage is commonly recommended to help athletes prepare both physically and mentally for a forthcoming competition (**Tappan & Benjamin, 1998**). The most important thing for athletes is performance. Sport massage is used both pre- and post-event in an attempt to enhance performance, overcome fatigue and help recovery (**Callaghan, 1993**). An increase in muscle blood flow would hasten the delivery of oxygen, increase muscle temperature and buffer blood pH, which would then aid in the sport performance (**Cafarelli & Flint, 1992**). As such, the sport massage provided 2 sessions a week is in this study is an effective post-training

recovery services to aid the athletes to optimise positive performance factors and enhancing their muscular performance.

Sauna bathing post-training recovery services was provided to the athletes in this study only on Fridays for the whole intervention period. The heat stress of a single session of sauna bathing produces hemodilution via an increase in plasma volume (**Hannuksela & Ellahham, 2001**). A reduction in renal blood flow during sauna bathing or the hemodilution resulting from the plasma volume expansion could provide the stimulus to produce more red cells via release of erythropoietin (**Scoon, Hopkins, Mayhew, & Cotter, 2007**). The resulting increase in total blood volume could enhance high-intensity endurance and strength performances by delivering more oxygen to muscles (**Scoon et al., 2007**). Sauna bathing is a type of heat exposure, which induces haemodynamic and endocrinological changes in some ways similar to those evoked by physical exercise (**Kukkonen-Harjula & Kauppinen, 2006**). In athletes, the traditional sauna has some positive effects on thermoregulation, if the competition is in a hot environment (**Tyka, Pałka, Tyka, Szygula, & Cisoń, 2008**). Also, during weight reduction, sauna bathing has been used successfully (**Mero, Tornberg, Mäntykoski, & Puurtinen, 2015**). In the recovery from physical exercise, sauna bathing has been used despite it seems that some other methods such as light aerobic exercise, nutrition, massage, sleep, rest are more efficient **(Ishak, Hashim, Ahmad, & Jawis, 2012**). The warm temperatures and cooling-off periods may relax muscles, nerves and blood vessels. This can produce a sensation of calm and relaxation. Since the participants of this study are in the midst of reducing their body weight, it is synchronized with their training periodization phase preparing for the upcoming competition.

During the intervention period, the athletes also were treated with High Intensity Laser Therapy (HILT) as one of the services on every Fridays after the sauna bathing sessions. HILT involves higher intensity laser radiation is a new, painless, and powerful modality that showed significant results in pain reduction **(Nazari, Moezy, Nejati, & Mazaherinezhad, 2019**). HILT with its own photo-chemical, photo thermal, and photomechanical actions has many therapeutic benefits including antalgic, anti-edema, and biostimulating effects **(Alayat, Atya, Ali, & Shosha, 2014**). Another advantage of HILT, especially on neodymium-dopedyttrium aluminum garnet laser, is its greater power and depth of penetration in deep tissues (**Sant'Anna et al., 2017**). HILT has satisfactory effects in treating pain (**Alayat et al., 2014**). The results of this study revealed that the muscular strength of bench press and dominant hand-grip were significantly improved between pre-intervention and post-intervention. Possible explanation is the HILT services provided aid in reducing muscles pain and inflammation of the related muscles, and ultimately improved the strength performance during post-intervention test. The current results supported by previous studies reported that positive effects of HILT on pain. HILT was more effective in the management of pain in patients with lumbar disc protrusion (Chen et al., 2018), plantar fasciitis **(Kaydok, Ordahan, solum, & Karahan, 2019**), males with osteopenia orosteoporosis (**Alayat, Abdel-Kafy, Elsoudany, Helal, & Alshehri, 2017**) and low back pain (**Ezzati et al., 2020**).

The final piece of post–training recovery services provided to the athletes in this study is the Kinesio taping at the shoulder and chest muscles. Resistance training with high intensity and eccentric contractions may cause muscle damage that may present itself as delayed onset muscle soreness (DOMS) (**Kırmızıgil et al., 2019**). DOMS is considered as a type I muscle strain (**Cheung, Hume, & Maxwell, 2003**). Also, stiffness, soreness, and tenderness of muscles are symptoms associated with DOMS (**Cheung et al., 2003**). In addition to the muscle soreness, the structural changes in muscle and connective tissue due to DOMS may impair muscle functions and joints' mechanical properties. Moreover, many researchers showed that DOMS is associated with a substantial decline in strength and power (**Mizumura & Taguchi, 2016**). Past studies reported that Kinesio taping (KT) would have beneficial effects on muscles soreness by ameliorating muscle function (**Mizumura & Taguchi, 2016**), inhibiting muscle activity , increasing blood and lymph circulation (Bischoff et al., 2018) and leading to neurological inhibition (**Ozmen et al., 2015**). Furthermore, KT, by lifting the skin, facilitates the removal of waste products and the increase of oxygen supply to the muscle and thereby may induce a recovery of muscle strength (**Ozmen et al., 2015**). In addition,

applying stretched KT in muscles pulls them and causes stimulation of Golgi tendon organ, which induces neurologic suppression resulting in pain reduction (**Ozmen et al., 2015**). KT is thought to increase blood circulation and muscle temperature by stimulating the vasomotor reflex. This increased metabolism may decrease pain (Ozmen et al., 2015). KT stimulates the cutaneous fusimotor reflex which in turn generates muscle contraction. Lymphatic and blood circulation is increased when muscle contraction occurs. (Ozmen et al., 2015).

In this study, the special designed resistance training program with 85% of 1RM consequence of inflammation due to micro tears occurring in muscle fibers or connective tissue damage is likely to be present particularly after the eccentric exercises inducing DOMS (Ozmen et al., 2015). Another study that using their own KT method with % tension had positive effects on the level of edema. In fact, KT reduced by 55% lymphedema after mastectomy (Pop, Karczmarek-Borowska, Tymczak, Hałas, & Banaś, 2014). As such, current findings supported that KT was an effective port-training recovery services to help the athletes in reducing the DOMS, muscles pain and recovered sooner after the resistance training sessions, and improved the strength performance.

Conclusion

It is predominant for athletes to footing training stress and succeeding recovery. When an athlete is exhibited to a training and competition stressors for too long, a state of ov*ertraining can happen* (**Kenttä & Hassmén, 1998**). Recovery phenomena is no different, if an athlete is not disclosing to the stressor high enough, a state of detraining can take place. Therefore, as a coach, monitoring should be a continuous process that includes physiological and psychological parts of the athletes during training and competition (**Kellmann, Altenburg, Lormes, & Steinacker, 2001**). Moreover, this case study involved the para elite athletes from Vietnam, in the case of the elite sporting environment where small changes in their performance often represent a meaningful difference for performance outcomes, informed decisions surrounding the context of post-training recovery services is of utmost importance.

Finally, there are some limitations in this study. First, the sample size is very small. Second, the findings of this study should only be applied to the para powerlifting athletes during general preparation phase in periodization plan.

Author Contributions

All author contributed equally in this study.

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Ethical Approval

This study received ethical clearance from the Institutional Review Board at University of Sports Ho Chi Minh City, Vietnam on 16 March 2022. The approved protocol encompasses the use of existing de-identified medical records for research on Effect of Embedded the Post-Training Recovery Services following Resistance Training on Muscular Strength in Vietnamese National Para Powerlifting Athletes – A Case Study

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