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Experimental Findings of Post-Performance Sports Massage Therapy on Stress and Mental State in Athletes

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Sports massage is a well-established form of manual intervention used to improve athletic performance. However, its impact on the biological, *physiological, and* psychological markers of mental state and stress remains unclear. This research seeks to elucidate the effect that sports massage, compression sleeves, and rest have on stress in the body. Stress will be quantified through amylase and cortisol levels, and on mood, expressed through Lifescore values using the program Lifescore Quick (LSQ), and the Profile of Mood States (POMS). To determine the extent of the impact that sports massage, compression sleeves, and rest have on salivary amylase (sAA), cortisol, LSQ, and POMS of a given test subject when administered after physical activity. Two subjects from the men's soccer team were tested using a crossover design on six occasions for salivary cortisol and sAA levels, LSQ, and POMS 5 to 10 min before and after regular practice. Following the second test, research subjects moved to the testing site and underwent one of three forms of intervention: full-body sports massage, compression sleeves, or rest. After treatment, they were tested a third time. 3 × 3 ANOVA with repeated measures was used for analysis, with within-subject factors being treatment condition and time. Obtained results reveal that both sports massage and compression sleeves are effective when compared to rest on salivary cortisol, sAA, Lifescore, and POMS, though under the present experimental condition no statistical significance was obtained between the two.

Key word: word; Massage therapy, Stress, Mental flexibility, POMS, Biomarkers, Individual

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Introduction

As a student attending a school of massage therapy, there was considerable information that the author accepted at face value without questioning too deeply: for instance, the oft-repeated statement that massage therapy heightens relaxation and decreases stress, which often seems to be the case for anyone who has received a massage. However, when confronted with questions from clients and other therapists about how the manual mechanisms of massage led to biological and chemical changes in the body indicating greater relaxation, I realized that my understanding of massage therapy remained shallow at best and that it deserved greater study.

There are a lot of talented athletes from many different disciplines in the university. Given that the university is renowned for its sports science and physical education, and in light of the fast-approaching Tokyo Olympic and Paralympic Games, it seemed to be the right time and place to conduct a study that would bring benefits to athletes just entering the peak of their ability by maintaining their health and improving the longevity of their performance. As such, this study was borne of the desire to contribute to the body of knowledge regarding massage therapy as well as to improve the quality of life and training of athletes.

This study seeks to determine the effects of sports massage, intermittent pneumatic compression (IPC) in the form of compression sleeves for the legs, and rest on stress and mood when given after team practice. The second form of experimental treatment, compression sleeves, were included as an alternative form of massage. It is completely automated from timing to the pressure used, making it both easy to use and to control in terms of variation, thus allowing easy comparison to the use of sports massage. Stress will be measured using the biochemical markers of cortisol and alpha-amylase, both drawn from saliva, and from pulse readings analysed through the program LSQ (Lifescore values). Mood will be self-reported using the POMS. These tests will be conducted before and after actual training and again after one of the three forms of intervention given above to determine the amount of change, if any, on stress and mood. The compiled data and results of this study can be considered in changes to rehabilitation and recovery methods of athletes at the University of Tsukuba.

Impact of Psychological Factors on Athletic Performance

1. Stress

Stress, defined as any physical, emotional, or mental pressure or demand that affects the homoeostasis of the body, can have a significant impact on an athlete's performance and recovery (Johnson et al., 1992). While a certain amount of stress is needed to fully activate an athlete's capabilities, excessive stress build-up from overtraining or under-recovery in their sport as well as personal stressors can lead to decreased productivity, long-term fatigue, and even burnout (Kellmann, 2002; Brink et al., 2010; Bali, 2015). Maximising an athlete's output necessitates taking stress management into consideration as part of their daily recovery. This study will use biological (biochemical-physiological-psychological) markers cortisol, salivary alpha-amylase (sAA), Lifescore Quick (LSQ), and the Profile of Mood States (POMS) to measure an athlete's stress level and mood, and are discussed further below.

2. Cortisol

Cortisol is a glucocorticosteroid released from the adrenal glands in response to both internal and external stressors in order to maintain homoeostatic balance within the body (Fukuda and Morimoto, 2001a; 2001b). In studies on a range of athletes, including swimmers (O'Connor et al., 1989), judo athletes (Filaire et al., 2001b), weight lifters (Passelergue et al., 1995), and soccer players (Haneishi et al., 2007), salivary cortisol was shown to increase alongside self-reported feelings of anxiety following overtraining and actual competition. However, higher levels of cortisol are not always a negative indicator of mental condition. In another study with judo athletes, Obmiński (2009) found that elevated cortisol levels indicated more motivation and orientation towards success, and overall the athletes with higher readings of cortisol and testosterone performed better at a major competition.

While cortisol is detectable in blood, there is a strong positive correlation between blood and salivary cortisol, the latter of which is quick and painless, giving it an advantage over needle-based blood collection (Jessop and Turner-Cobb, 2008).

3. Alpha-Amylase

Alpha-amylase (also α-amylase) is an enzyme found in the saliva that has been increasingly linked to activity of the sympathetic nervous system (Nater and Rohleder, 2009). Studies have shown sAA to increase not only during mental (Bosch et al., 1996; Noto et al., 2005; Goi et al., 2007) and social (Yamaguchi et al., 2006; Stroud et al., 2009) stress, but also during physical stress, as seen in crew (Kivlighan and Granger, 2006), Taekwondo (Chiodo et al., 2011), and swimming (Diaz et al., 2012) disciplines. Like salivary cortisol, sAA is easily collected without contributing any additional stress to the research subject.

4. Lifescore

The LSQ is a program developed by Professor Mayumi Oyama of Osaka University (Japan). Using the pulse found in the fingertip, this program quantifies the level of stress/relaxation in the body as well as mental flexibility. Stress and relaxation are measured through pulse fluctuations, where larger gaps between the crests of each pulse wavelength indicate greater amounts of relaxation, while the opposite indicates greater amounts of stress. Mental flexibility is analysed through the shape of each pulse, and a higher reading indicates a greater amount of susceptibility to environmental influence, while a lower reading indicates a higher degree of indifference to one’s surroundings (WIN Frontier, 2017). While the preferred degree of mental flexibility depends on the situation, in the case of athletes, a lower reading of mental flexibility would presumably be more advantageous, as they would be less susceptible to the stress and pressure of competition. LSQ has been used in recent studies on heart rate (Komazawa et al., 2017), the effect of plants in the workplace on physiology and psychology (Genjo and Matsumoto, 2016), and autonomic nervous function (Komazawa et al., 2016; Itao et al., 2017).

However, it should be noted that the existing body of literature related to LSQ remains small, with study authors linked to the makers of the program. The usage of LSQ and especially mental flexibility has not been vetted by the wider academic community, and understanding of its more specific applications, including to sport, is not yet widespread. While this study includes the mental flexibility parameter, its use remains tentative as an actual measurement of stress.

5. Profile of Mood States

The POMS is a widely-recognised measure of mood and psychological distress. Developed by McNair and co-workers in 1971, 1981, and 1992, both the 65-question original and the 37-question shortened version of the test ask respondents to rate themselves in the areas of tension, depression, anger, vigour, fatigue, and confusion and have been frequently used to examine the relationship between mood state and athletic performance (McNair et al., 2003). The iceberg profile is a descriptor of the visual representation made when plotting overall low raw scores for negative descriptors (tension, depression, anger, fatigue, and confusion) and high raw scores for positive descriptors (vigour) and is considered ideal (Rowley et al., 1995). As salivary cortisol, sAA, and LSQ are quantitative measurements based on biological readings, the POMS was included in the experimental design to provide a qualitative angle to complement the analysis.

Method

The methodology of this study was constructed based on several conclusions drawn from the previous research. Performance factors were not tested in this study as they are rarely influenced by sports massage; however, there remained a further need to examine the psychological benefits

(Hemmings, 2001; Micklewright et al., 2005; Weerapong et al., 2005; Goodwin et al., 2007). A majority of previous experiments took place entirely in a lab setting or under controlled conditions and did not have subjects undergo testing during regular training, which was another area requiring greater consideration. The current study's particular combination of cortisol, sAA, LSQ, and POMS has not been used elsewhere and was developed for the study's particular parameters.

The intent of this study was to examine the effects of the experimental protocol when conducted as part of real-life training, so no measurements of physical performance or unaccustomed exercise occurred within a laboratory setting. The frequency of experiments was determined based on each research subject's practice and competition schedule. As the competitive season was over at the time experimentation began, no official matches were played, though regular soccer practises continued. No experiments were conducted on days with early morning or high-intensity practices, due to possible fluctuations in cortisol or alpha-amylase.

1. Subjects

Two male research subjects, both 20 years of age, from the men's soccer team at the University of Tsukuba volunteered to participate in this study. The research subjects each have 15 years of playing experience and regularly participated in both practises and matches. Potential subjects were excluded if they had had any major surgeries within the past year or a significant injury during the previous season. Both research subjects experienced all three forms of treatment and were notified at the time they reached the lab of that day's treatment method. As experiments occurred according to each test subject's personal schedule, on some days both test subjects underwent simultaneous testing of different treatments, while on others only one test subject underwent testing.

2. Procedures

The first pre-training test occurred 10-15 min prior to the start of practice at the First Soccer Ground at the University, when subjects were going through individual warm-ups. Subjects then proceeded to go through practice as usual, and within 5 to 10 min after the end of practice, when all players were dismissed by their coach, the second test was administered. In the following 30 min, subjects could complete their cooldown, attend to any team-related tasks such as equipment clean-up, change clothes, and move to the testing site. Subjects were asked not to leave the vicinity of the First Soccer Field for the duration of that 30 min until they were ready to move to the next step of the experiment.

Upon arrival at the testing site, the test subject would be then prepared to receive one of the three forms of intervention as follows: a 10-min full-body sports massage, 10 min of IPC treatment using compression sleeves on the legs, or 10 min of quiet rest were administered. Following the intervention, the subject completed the third and final set of data collection tests, at which point the experiment session for that day was completed.

3. Data Collection

Data collection for salivary cortisol, sAA, Lifescore (LSQ), and POMS occurred at three points: during individual warm-up before commencing training, after training, and after intervention. The first two tests occurred at the soccer ground, and the third at the testing site. Saliva was collected for cortisol testing and then placed in a cold (ice) storage box until it was brought back to the testing site, at which point it was transferred to the freezer, and stored at -4 degrees Celsius until analysis. As on-site data collection took place outside, temperature and weather conditions could not be controlled but were noted down. The testing site in Collaborative Research Building A, room 310, was temperature-controlled to 20 degrees Celsius.

1) Salivary Cortisol

Cortisol peaks 20 to 30 min after awakening in a phenomenon known as the cortisol awakening response (CAR) and then declines throughout the course of the day (Fries et al., 2009). A sharper and longer increase on awakening has been observed in those who wake up in the very early hours, from 4:00-5:30, in comparison to those who wake up later, from 6:00-9:00 (Federenko et al., 2004). CAR also appears to increase when there are anticipated stressors, such as work, early in the morning (Williams et al., 2005). Depending on both team level and personal habits, some test subjects may wake up much earlier than others, which could lead to significant variability between otherwise physically similar subjects. Due to the possibility of deviations of an unknown scale from baseline cortisol levels, morning practices were not included as part of the experiment. Approximately 0.1 mL of saliva was collected via passive drool and frozen at -30ºC until analysis.

2) Salivary Alpha-Amylase

The salivary amylase monitor that was used was produced by Nipro (Osaka, Japan), model DM-3.1. To measure sAA, a measurement tab is placed under the tongue for 30 sec and then is inserted into the Nipro salivary amylase monitor for analysis. Results are immediately displayed in kilo-International Units per litre. A range of 1-30 kIU/L is considered to be stress free, with values from 31-34 kIU/L mildly stressed, 46-60 kIU/L stressed, and values over 60 highly stressed (Shinwa-Musen, 2017).

According to the operating manual of the salivary amylase monitor, it is best to refrain from eating 1-2 h and drinking or gargling for at least 5 min before measurement, as the effects of digestion and swallowing can affect saliva production and in turn sAA readings. Due to that restriction, practices including high-intensity training were omitted as part of the experimental study, as members of the soccer team reported that it would be ill-advised to attend practice without proper nutrition beforehand, and refraining from water intake immediately afterward would be difficult. In addition to the morning cortisol fluctuations mentioned above, some members of the team reported waking up early enough before morning practices to eat breakfast, but depending on practice time, wake-up time and food consumption would vary considerably. Because of the possibility of confounding either the cortisol or sAA readings, morning practices were also omitted from the experimental study.

3) Lifescore Quick

The LSQ value is measured using a pulse sensor that clips over the fingertip. This sensor is connected to a PC (LetsNote, Panasonic, Japan) via a USB cable. The computer program then reads the pulse through the attachment and determines the level of stress and mental flexibility based on several categories, including highest, lowest, and average pulse (WIN Frontier, 2017). While the test includes a short nine-question section after the results of the pulse reading that asks respondents to report on their mood and feelings, this section was not included as a point of analysis.

4) Profile of Mood States

A 35-question, Japanese language version of POMS (POMS 2; Kaneko Shobo Company, Tokyo, Japan) was administered to test subjects, and their responses were calculated and compiled after each experiment.

4. Forms of Intervention

As this study incorporates a within-subjects design, all test subjects underwent each form of intervention a minimum of two times. Subjects were free to engage in conversation and to ask any questions throughout the treatment session, but were asked not to use their phones during the treatment.

1) Sports Massage

The sports massage protocol was developed based on personal experience and knowledge and is meant to reflect a sports massage that may be safely administered to any athlete regardless of their sport. A 10-min-long post-event sports massage routine is typical while not being so long as to be intrusive to the athlete. The timing was also selected to mirror the length of the compression sleeve protocol, which can only be administered in 10 min segments.

2) IPC - Compression Sleeves

The compression sleeves are a pneumatic compression device produced by Dr. Medmer (Nikko Kohki Company, Tokyo, Japan), model DM-6000, and have four modes: Web, Squeeze, Hyper, and Course, all of which are set to 10 min in length. Web mode individually compresses each of four sections of the leg or arm, beginning with the most distal end and moving proximally; Squeeze mode compresses each section of the leg or arm in addition to the section(s) that came before it, beginning with the most distal end; and Hyper mode compresses all four sections simultaneously with increasing pressure. Course mode cycles through all three and was used while set to pressure level 3 of 5. While there was the option to use both a single arm sleeve and sleeves for both legs, as the subjects were all drawn from a soccer team, only leg sleeves were used.

3) Rest

The rest intervention consisted of the test subject lying quietly supine for 10 min on the same massage table on which the sports massage intervention was conducted.

5. Statistical Analysis

Statistical analyses were performed using SPSS software version 24 (SPSS, SPSS Inc, Chicago, Illinois, USA). Parasympathetic, sympathetic, and total power values from Lifescore; Anger-Hostility (AH), Confusion-Bewilderment (CB), Depression-Dejection (DD), Fatigue-Inertia (FI), Tension-Anxiety (TA), Vigor-Activity (VA), and Total Mood Disturbance (TMD) from the POMS; and salivary cortisol and sAA were individually analysed using 3 × 3 ANOVAs for repeated measures, with within-subject factors treatment being condition (control, sports massage, and compression sleeves) and time (pre-practice, post-practice, and post-treatment). Bonferroni corrections were applied to significant F values, and statistical significance was accepted at $p < 0.05$.

Results

1. Results of Pilot Study

The methodological approach was developed following two pilot studies conducted. The preliminary research subjects were not athletes and therefore not accustomed to regular practice or competition at the level of intensity as the test subjects in the experimental study.

1) First Experiment

The first test began with one female of 26-years of age and one male of 23-years of age volunteered for the experiment. Both subjects underwent baseline testing after 15 min of rest, which consisted of the salivary cortisol, sAA, and LSQ tests. The female test subject received 10 min of sports massage protocol, while the male test subject received 20 min of compression sleeve intervention. All three tests were conducted again after each subject's intervention.

The results of both salivary cortisol and sAA levels generally decreased for both subjects following the respective forms of intervention. Salivary cortisol levels decreased by 0.094 ug/DL for sports massage in comparison to 0.063 ug/DL for compression sleeves. Based on the sAA measurements, both test subjects can be considered stress-free both before and after each form of intervention. While the female test subject's sAA level decreased following sports massage intervention, the male test subject's sAA level rose following the compression sleeve intervention. This may have occurred due to undisclosed food or liquid consumption immediately prior to the baseline test, which would affect sAA readings.

According to the result, the female test subject's stress level decreased and mental flexibility increased following intervention. A stress/relaxation value below 5 indicates activation of parasympathetic nerves, which is also indicated by the increase in parasympathetic value. Pulse rate also fell, indicating greater relaxation. In the case of the male test subject stress level decreased while mental flexibility increased. Parasympathetic nerve activation rose considerably along with a decrease in stress/relaxation value. Overall pulse rates decreased following intervention.

2) Second Experiment

The second test with one male test subject, 23-years of age, volunteered for this experiment. The purpose of this second experiment was to include simulation of fatiguing exercise to examine the changes to salivary cortisol and sAA. Unfortunately, due to technical issues, LSQ was not available for testing in the second experiment. The fatiguing exercise does not closely mimic any one sport but was developed with the intent to induce fatigue the test subject as much as possible.

Salivary cortisol levels changed little for the first four tests, despite the fourth test occurring after the first round of fatiguing exercise. Cortisol increased by 0.078 ug/DL following the sports massage intervention that followed immediately after, and jumped again by 0.061 ug/DL after the second round of fatiguing exercise. After the final round of intervention, which were leg compression sleeves, cortisol dipped by ug/DL, the greatest reduction throughout the experiment. The sAA levels remained similar for the first three tests and increased following both rounds of fatiguing exercise but decreased after both forms of manual intervention. All sAA levels remained within the range of stress free.

2. Experimental Results

1) Salivary Cortisol

Table 1 lists the amount of cortisol found in collected saliva at each point of testing. In general, cortisol increased following practice and decreased following all forms of intervention. Average percentage change from post-practice to post-treatment was -23.07% for sports massage, -33.75% for compression sleeves, and -35.41% for rest; average percentage change from pre-practice to post-treatment was -13.19%, 0.62%, and 24.55%, respectively. Statistical analysis did not reveal any significant data.

Table 1. *Mean salivary cortisol readings*

Experimental Results – Salivary Cortisol (ug/DL)			
	Pre-practice	Post-practice	Post-treatment
Sports massage	0.144 ± 0.08	0.186 ± 0.09	0.125 ± 0.04
Compression sleeves	0.161 ± 0.04	0.23 ± 0.10	0.162 ± 0.05
Rest	0.110 ± 0.03	0.239 ± 0.11	0.137 ± 0.04

Data presented are mean ± SD

However, when the average percent change from post-practice to post-treatment and overall percent change was examined by subject, individual variability became much more apparent. Table 2 below lists how each form of treatment impacted cortisol following practice, and how cortisol changed overall from start to finish. For subject 1, the greatest change from post-practice to post-treatment was compression sleeves, while for subject 2 it was rest. When looking at how overall cortisol levels were impacted from the start of the experiment to the end, sports massage was the most effective for both subjects.

Table 2. *Mean change in cortisol levels from post-practice to post-treatment, and pre-practice to post-treatment by subject*

Experimental Results – Salivary Cortisol Percent Change				
	Subject 1		Subject 2	
	Post-practice → Post-treatment	Pre-Practice → Post-treatment	Post-practice → Post-treatment	Pre-Practice → Post-treatment
Sports massage	-12.79%	**-24.28%**	-33.36%	**-40.1%**
Compression Sleeves	**-41.65%**	-10.97%	- 25.85%	24.08%
Rest	-15.76%	-6.98%	**-55.06%**	59.96%

2) Salivary Alpha Amylase

Table 3 below lists the values as given by the Nipro salivary amylase monitor, which provided readings immediately at both testing sites on the field and in the laboratory. The Nipro data did not produce any significant values after statistical analysis. Compared to post-practice values, the treatment with the greatest post-treatment reduction is compression sleeves—in fact, sports massage and rest both resulted in higher sAA values post-treatment. When compared with pre-practice values, all post-treatment values had increased. The mean percent changes in sports massage, compression sleeves, and rest from post-practice to post-treatment were 1.04%, -32.52%, and 68.35% respectively, while mean percent changes from pre-practice to post-treatment were 38.57%, 16.9%, and 47.78% respectively.

Table 3. *Mean sAA readings by Nipro salivary amylase monitor*

Experimental Results – sAA (kIU/L), Nipro			
	Pre-practice	Post-practice	Post-treatment
Sports massage	17.5 ± 15.61	24 ± 16.63	24.25 ± 15
Compression sleeves	17.75 ± 13.62	30.75 ± 28.34	20.75 ± 11.09
Rest	22.5 ± 20.63	19.75 ± 18.43	33.25 ± 35.2

The sAA values are given again, split by subject, above in Table 4. Most forms of treatment resulted in considerable increases to sAA, the only exceptions being the -31.05% decrease form post-practice to post-treatment for compression sleeves and the overall -23.6% decrease from pre-practice to post-treatment for the first test subject.

Table 4. *Mean change in sAA readings by Nipro from post-practice to post-treatment, and pre-practice to post-treatment by subject*

Experimental Results – sAA Percent Change (Nipro)				
	Subject 1		Subject 2	
	Post-practice → Post-treatment	Pre-Practice → Post-treatment	Post-practice → Post-treatment	Pre-Practice → Post-treatment
Sports massage	13.6%	**-23.6%**	70.4%	164.29%
Compression Sleeves	**-31.05%**	17.23%	216.5%	65%
Rest	67.13%	86.56%	85%	87.5%

The saliva samples collected for cortisol analysis were then additionally tested for sAA levels using enzyme activity analysis, the results of which are given below in Table 5.

Table 5. *Mean sAA readings by Salimetrics analysis*

Experimental Results – sAA (IU/L), Salimetrics			
	Pre-practice	Post-practice	Post-treatment
Sports massage	9.88 ± 8.05	8.25 ± 4.57	8.63 ± 11.34
Compression sleeves	10 ± 5.77	11.88 ± 10.44	5.25 ± 4.35
Rest	7.25 ± 4.03	9.25 ± 4.97	5 ± 3.83

Salimetrics analysis revealed that post-treatments sAA values were lower compared to pre-practice values, and in all cases except for sports massage, post-treatment values were lower than post-practice values as well. Mean percent changes from post-practice to post-treatment were 2.86% for sports massage, -58.6% for compression sleeves, and -55.05% for rest; for pre-practice to post-treatment, the values were -15.20%, -50.09%, and -33.37%. The only values of statistical significance occurred with compression sleeves (p = 0.011) when comparing pre-practice values with post-treatment values, and with rest (p = 0.028), also when comparing pre-practice with post-treatment. The difference between laboratory analysis and Nipro readings may be attributable to the Nipro's small, transportable nature, which may come at the cost of some accuracy.

Table 6. *Mean change in sAA readings using Salimetrics from post-practice to post-treatment, and pre-practice to post-treatment by subject*

Experimental Results – sAA Percent Change (Salimetrics)				
	Subject 1		Subject 2	
	Post-practice → Post-treatment	Pre-Practice → Post-treatment	Post-practice → Post-treatment	Pre-Practice → Post-treatment
Sports massage	-23.55%	**-21.61%**	-33.36%	14.02%
Compression Sleeves	**-26.16%**	-13.6%	-25.85%	24.08%
Rest	-20.48%	-1.47%	**-55.05%**	57.77%

Despite the differences in the raw data between the Nipro monitor and enzyme activity analysis, the individual breakdown of the latter values reflects, in general, the same trends seen in the Nipro values. Subject 1's sAA levels responded to all forms of treatment both overall and from post-practice to post-treatment, while the second test subject did not see any decreases overall, but saw improvement from post-practice to post-treatment (Table 6).

3) Lifescore Quick

Table 7 below provides three main Lifescore values (LSQ). The rest treatment provided the greatest boost to the parasympathetic nervous system, while compression sleeves had the lowest reading of sympathetic values post-treatment. Total Power was highest with the rest treatment. ANOVA testing did not reveal any values of significance for parasympathetic, sympathetic, or total power scores.

Table 7. *Selected mean Lifescore readings*

Experimental Results – Lifescore Values									
	Parasympathetic			Sympathetic			Total Power		
	Pre-Pr	Post-Pr	Post-Tr	Pre-Pr	Post-Pr	Post-Tr	Pre-Pr	Post-Pr	Post-Tr
Sp Ma	17.79 ± 10.09	8.69 ± 7.96	42.13 ± 63.13	44.9 ± 37.89	59.9 ± 72.86	62.56 ± 55.02	77.8 ± 70.34	74.98 ± 86.59	109.92 ± 113.13
CS	26.56 ± 24.18	9.73 ± 4.48	36.28 ± 27.196	26.94 ± 32.14	33.86 ± 36.34	30.67 ± 26	53.46 ± 55.99	43.6 ± 39.99	66.96 ± 51.9
Rest	27.06 ± 12.61	11.63 ± 10.19	80.5 ± 124.117	25.67 ± 24.81	17.91 ± 22.03	76.44 ± 82.75	52.73 ± 36.4	29.54 ± 30.9	156.94 ± 205.28

Pre-Pr = Pre-practice, Post-Pr = Post-practice, Post-Tr = Post-treatment; Sp Ma = Sports massage, CS = Compression sleeves

Figure 1 depicts the graphs generated by the Lifescore Quick program that visually plots the research subject’s level of stress and mental flexibility for the first subject. In each graph, the heart symbol marked with 1 represents the pre-practice reading, 2 represents post-practice, and 3 represents post-treatment. The higher the heart symbol is on the vertical axis, the more mental flexibility the subject is experiencing, whereas the farther right the symbol is placed, the more stressed the subject feels. Movement from pre-practice to post-practice to post-treatment is represented by yellow arrows. ‘Light’ or ‘moderate’ in parentheses following the type of treatment indicate the intensity of training on the day of testing. The graph is divided into four quadrants representing emotions. The upper left area is ‘uplifted,’ characterized by low stress and high mental flexibility. The upper right is ‘tension,’ with high stress and high tension. The lower left is ‘relaxed,’ with low stress and low mental flexibility. The lower right is ‘depressed,’ with high stress and low mental flexibility.

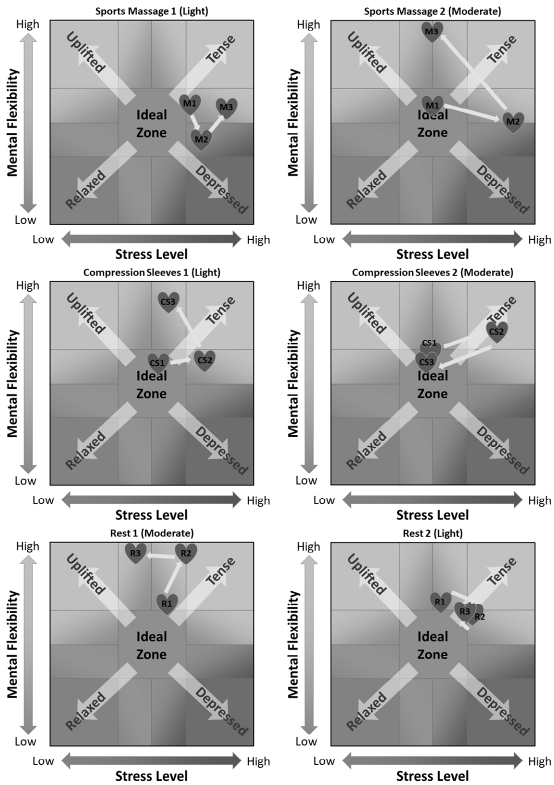

Figure 1. *Lifescore Quick graphs for Subject 1*

In every instance, Subject 1's stress increased following training, which is not unexpected. The use of an IPC device, the compression sleeves, returned the subject to similar levels of baseline stress, and in the case of rest, the level of mental flexibility post-treatment was similar to that of post-training. The first and second experiments using sports massage treatments differ significantly from each other, with the first returning the subject to a similar level of mental flexibility but with increased stress, while the second sports massage treatment returned the subject to baseline levels of stress, but with much heightened mental flexibility. The second research subject's Lifescore graphs are given below in Figure 2.

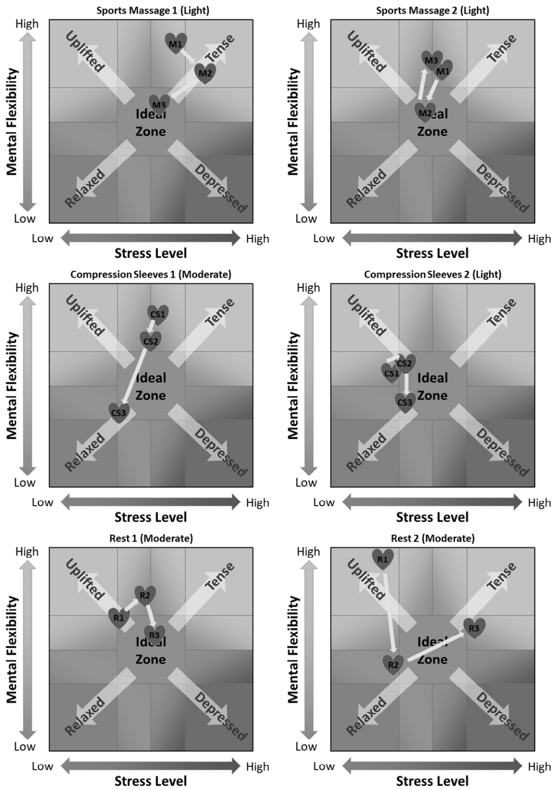

Figure 2. Lifescore Quick Graphs for Subject 2

In the case of Subject 2, stress did not always increase following training as it did with Subject 1, and sometimes it even decreased. The massage treatment returned the subject to approximately the same level of pre-practice stress, though in one case it decreased mental flexibility and in the other returned it to slightly higher than baseline levels. Compression sleeves decreased mental flexibility overall, though stress levels remained roughly the same from start to finish. Rest appeared to increase the subject's stress when compared to pre-practice levels.

4) POMS

The tables 8 provide the averages of all the tested POMS values. For the entirety of POMS values, statistical analysis revealed no significant findings. Table 10 lists the mean AH values taken from POMS. Of the treatments provided, only sports massage decreased the reported AH value compared to both pre- and post-practice, while the post-treatment value for the rest treatment was comparatively higher.

It displays the mean TA values from POMS, which show that sports massage had the overall best effect on reducing TA when compared to compression sleeves and rest. Compression sleeves led to an increase in TA, while the changes after rest were minimal. The result of POMS (TA) can be seen that all three forms of treatments did not have much of an effect on CB overall. As with CB values, the DD values as given in Table 10 did not change drastically with any form of treatment, but all improved DD values from post-practice as well as pre-practice. In case of POMS (FI) nearly all FI values increased by post-treatment, except for the decrease from post-practice to post-treatment in the case of sports massage. VA values decreased in general but increased from post-practice to post-treatment only in the case of sports massage. Lastly, TMD increased for both compression sleeves and rest overall, while in the case of sports massage, it remained roughly the same when compared to pre-practice readings, but decreased following treatment after practice.

Table 8. *POMS values*

Experimental Results		Pre-practice	Post-practice	Post-treatment
POMS (AH)	Sports massage	43.25 ± 6.7	50 ± 13.37	40.25 ± 3.3
	Compression sleeves	38.5 ± 1	40 ± 1.63	39 ±1.15
	Rest	39.5 ± 1.91	38.5 ± 1	43.25 ±6.7
POMS (TA)	Sports massage	41 ± 5.03	42.75 ± 9.78	37.25 ± 4.72
	Compression sleeves	37.75 ± 5.68	36 ± 2.45	39 ± 6
	Rest	39.5 ± 2.89	38.25 ± 5.68	38 ± 4.62
POMS (CB)	Sports massage	41.25 ± 2.06	46.75 ± 8.1	40 ± 1.15
	Compression sleeves	41.75 ± 2.99	41.25 ± 2.06	41.25 ± 2.06
	Rest	42.5 ± 4.36	40 ± 1.15	42.5 ± 4.36
POMS (DD)	Sports massage	43.75 ± 2.96	44.75 ± 2.5	43 ± 2.45
	Compression sleeves	45.75 ± 4.03	46.25 ± 6.18	43.75 ± 2.06
	Rest	43.25 ± 1.5	41.75 ± 1.5	41 ± 0
POMS (FI)	Sports massage	43.5 ± 5.32	48 ± 15.12	44.5 ± 9.73
	Compression sleeves	39.75 ± 3.86	42.25 ± 4.78	46.5 ± 7.68
	Rest	41.75 ± 5.43	42.5 ± 8.18	43.5 ± 8.66
POMS (VA)	Sports massage	64.75 ± 14.63	57.25 ± 24.05	59.25 ± 21.84
	Compression sleeves	67.5 ± 9.04	65 ± 10.55	55.25 ± 22.85
	Rest	62 ± 11.86	62.5 ± 17.71	55.75 ± 24.64

Experimental Results		Pre-practice	Post-practice	Post-treatment
POMS (TMD)	Sports massage	38.75 ± 6.86	45 ± 14.9	38.75 ± 8.73
	Compression sleeves	36.5 ± 4.73	38.25 ± 3.95	41 ± 8.12
	Rest	38 ± 5.94	37.25 ± 7.41	40 ± 10.52

Discussion

When broadly considering the outcomes of treatment, the results are so scattered as to prevent a conclusive determination of whether one form of treatment is truly better than another. Compression sleeves and rest were about equally as good at reducing cortisol from post-practice to post-treatment, but sports massage was more effective when considering values from pre-practice, and both test subjects individually favoured the sports massage treatment as well. All three forms of treatment did not have much of an effect on sAA according to Nipro readings; based on enzyme activity analysis, however, IPC and rest were almost equally effective in reducing sAA overall. Control treatment heightened parasympathetic values and total power the most based on Lifescore values, possibly due to the parasympathetic nervous system requiring actual rest, rather than any sort of movement from massage or compression, in order to activate. Given that throughout the entire study, only two values of significance—IPC and rest in reducing sAA, as measured by Salimetrics—were actually found, however, these conclusions are more of suggestions based on where the data pointed.

The Lifescore plots of stress versus mental flexibility, like the previous data on sAA and cortisol, provide mixed results. Even when comparing from pre-practice to post-treatment and post-practice to post-treatment, no trends become evident based on treatment or even intensity of practice. The first subject tended to stay more towards the upper right of the graph, which is high stress and high mental flexibility, and only ended in the ‘ideal zone’ once out of six treatments, and that was after the treatment using compression sleeves. While the changes in his mental flexibility varied from very little to a moderate amount, his stress level remained within a smaller range and did not experience as much change no matter the form of treatment. In the case of the second subject, whose post-treatment score landed in the ‘ideal zone’ three times—once out of every form of treatment—mental flexibility underwent relatively greater changes than stress, the same as with the first subject. The second subject stayed closer to the middle and left side of the graph, indicating his tendency towards lower stress and mental flexibility compared to the first subject. When considering the intensity of the practice, greater movement was seen with moderate practices than with light practices, but this is still not a reliable predictor of movement towards one particular direction of stress or mental flexibility. Drawing conclusions based on this handful of findings alone is not advised, however, until critical research using LSQ and mental flexibility in particular has progressed further.

In general, sports massage was the most effective in improving all subscales of POMS. In the case of AH, TA, FI, and TMD, it was the only treatment to improve or at least bring the subject back to their pre-practice values, while the other treatments either remained the same or worsened. CB values remained roughly unchanged from start to finish for all treatments, but rather than meaning treatments were not effective, confusion and bewilderment may not be emotions frequently experienced during regular training compared to feelings such as anger, tension, and fatigue. All three forms of treatment improved DD, though only slightly; again, depression and dejection are likely not commonly-felt emotions during practice. Interestingly, while only sports massage had some effect on reducing FI, all three forms of treatment had a positive impact on boosting VA as well. Therefore, while sports massage, compression sleeves, and rest all improved the sensation of vigour and activity, only sports massage decreased the sense of fatigue and sluggishness felt in the body, however slightly.

The majority of previous studies that included POMS as an area of study found little evidence that sports massage had an effect on mood. Studies by Hilbert et al. (2003) and Crow (2015) did not measure POMS immediately after physical activity or treatment, instead waiting 4-6 h before administering the test, with mood likely fluctuating in the meantime. The present study measured POMS immediately after training, similar to the study by Guest (2010), where POMS was given soon after treatment and no changes were found. However, perceived recovery was noted to be higher in the group that received massage, indicating that even if there were no discernible effects on mood, mental state appeared to have been uplifted. As with the results of the current study, Arroyo-Morales et al. (2011) found improvement in the tension subscale of POMS, though no other subscales were affected, most likely due to the massage being given before activity rather than after. Gwynne's 2012 study found improvement in FI following pre-event sports massage and sprints; again, however, as with Arroyo-Morales and co-workers' study, if reassessment is not made immediately after treatment, the impact of that treatment on mood is lost (Gwynne, 2012).

This study emphasised the importance of taking individual variability into consideration when examining results. The use of only two test subjects is admittedly small, and as such differences in personality and individual reactions to treatment become heightened. One test subject, who had a more excitable and extroverted nature, consistently had much higher sAA readings and much lower POMS scores, and tended to have higher stress and mental flexibility, which clearly skewed the aggregate results; looking at the trends in his individualised response to treatment, however, he generally reacted better to sports massage. The other test subject, meanwhile, had a calmer and more introverted disposition and had consistently low sAA values, higher POMS scores on average, and had less stress and lower mental flexibility, and he did not appear to show a strong inclination toward either form of experimental treatment. In the hypothetical case that these two subjects were high-performing, valuable players on a professional team, consideration could be given to investing in two separate methods of treatment, though it may be expensive, given the stark differences in their personal and biochemical/physiological makeup.

Conclusion

This research aimed to determine the impact of post-performance sports massage, leg compression sleeves, and rest on biological markers of stress as well as mood, namely, biochemical-physiological-psychological. While statistical analysis revealed no major differences of significance between the use of sports massage or compression sleeves when compared to rest on salivary cortisol, sAA, Lifescore, and POMS, the sports massage treatment lowered cortisol the most overall from pre-practice to post-treatment, whereas compression sleeves were more effective for lowering cortisol from post-training to post-treatment. According to the Nipro measurements, compression sleeves were the most effective for lowering sAA values from post-practice to post-treatment, but overall all sAA values rose by the time of post-treatment measurement when compared to pre-practce values. Analysis using Salimetrics, meanwhile, indicated that all three forms of treatment improved sAA from start to finish, but compression sleeves and rest lowered sAA from post-practice to post-treatment and produced the only results of statistical significance in this study. The control treatment of rest was most effective in boosting parasympathetic and total power readings from Lifescore, while compression sleeves minimized sympathetic activation the most. Of the POMS subscales, sports massage was most effective overall for all tested values.

It was also determined that when data from both subjects was analysed together to look for general patterns throughout all experiments, distinguishing individual differences were erased. While performing statistical analysis on only a handful of experiments would likely not lead to data of real significance, such wide variations only point to the importance and perhaps necessity of customising treatments to the individual based on what they respond to, rather than attempting to apply a blanket treatment to an entire team.

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