Chase Trainer Exercise Program in Athlete with Unilateral Patellofemoral Pain Syndrome (PFPS)

Asha Hasnimy Mohd Hashim and Lee Ai Choo

***Abstract*—**We investigated the effects of modified preprogrammed training mode Chase Trainer from Balance Trainer (BT3, HurLab, Tampere, Finland) on athlete who experienced unilateral Patellofemoral Pain Syndrome (PFPS). Twenty-seven athletes with mean age= 14.23 ±1.31 years, height = 164.89 ± 7.85 cm, weight = 56.94 ± 9.28 kg were randomly assigned to two groups: experiment (EG; n = 14) and injured (IG; n = 13). EG performed a series of Chase Trainer program which required them to shift their body weight at different directions, speeds and angle of leaning twice a week for duration of 8 weeks. The static postural control and perceived pain level measures were taken at baseline, after 6 weeks and 8 weeks of training. There was no significant difference in any of tested variables between EG and IG before and after 6-week the intervention period. However, after 8-week of training, the postural control (eyes open) and perceived pain level of EG improved compared to IG ($p<0.05$). The postural control with eyes closed of EG improved ($p<0.05$) but the values were not significantly different compared to IG after training. The results suggest that using Chase Trainer exercise program it is possible to improve individual postural control and decreased perceived pain level in athlete with unilateral Patellofemoral Pain Syndrome (PFPS).

***Keywords*—**Patellofemoral Pain Syndrome, perceived pain level, postural control.

I. Introduction

PATELLOFEMORAL PAIN SYNDROME (PFPS) is one of the most common orthopedic conditions reported in adolescents and young adults especially in individual who engaged in regular physical activities such as athlete [1]–[4]. PFPS is usually referred as anterior knee pain (AKP) or runner's knee as it common in runners and other endurance athletes [5]

This symptoms also reported in sports that involved movement of jumping, cutting and pivoting or repetitive bearing in the lower limb loading [6], [7]. In terms of percentange, this syndromes have been reported to affect approximately 30% of young athlete (13-19 years) within 5.7 years of follow-up and 74% of them limit their sport activities and some of them stop participating [8]. Based from these evidences, individual who experienced PFPS may limit their participation in physical activities due to pain sensation thus may limit them from the health benefit.

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Up to this date, there are various numbers of approaches have been proposed and applied in order to manage PFPS symptoms ranging from complete rest on bed to various intervention such as muscle strengthening, stretching, manual therapy, patellar taping, bracing, orthoses, electric stimulation and electromyographic (EMG) biofeedback [9]–[13]. However, studies showed that approximately 25% of patients continued to have pain and dysfunction for more than one year after physiotherapy has been completed [14] thus its effectiveness still remains unclear [11].

This unresolved problem has led to lack of program theory failure in which the developed intervention either it is too complex for the setting to be implemented or does not lead to the desired behavior change because of the way it was designed. To cater the critical need of PFPS rehabilitation, patients were prescribed and urged to follow a series of leg strengthening exercise which was lack of evidence-based approach and time consuming [10]. Thus, it will influence the effectiveness of intervention. **S**ince at the beginning of the PFPS rehabilitation program, there has been a perceived discrepancy between what behind the theory and what is practiced in real situation. This condition will make the rehabilitation process become more difficult and complicated. Therefore, to ensure the PFPS rehabilitation process is at the maximum patch, a strong need for a better organized approach which would provide the patient with consistent and sustained theory-practiced during the rehabilitation process. Therefore despite of prescribed training program other aspects such as adherence and appraisal process appears to be underused, unsupported and unmonitored [15]. Hence these aspects need to take account too.

By simply restoring mechanical restraints as presented by previous studies is seems not enough for a functional recovery of the PFPS because the coordinated neuromuscular controlling mechanism is required during daily living and sports specific activities. The effectiveness of neuromuscular training in reducing the incidence of certain types of sports injuries among adolescent and young adult athletes such as ankle sprains and hamstring injuries had been proven [16] but, there is still lack of evidence that can support the effectiveness of this training method when it applies to PFPS patients. As we know the objective of neuromuscular training is to improve the nervous system's ability in order to generate fast and optimal muscle firing pattern thus increase dynamic joint stability [17], [18]. Therefore, by emphasizing this type of exercise in PFPS rehabilitation programs it will be able to improve the strength, function, and efficiency of biomechanical deficiencies which will greatly improve the alignment of the patella, enhance the patient's function, and greatly reduce the risk of future recurrence.

Most of physiotherapist and physician use a task-oriented approach which focusing on function and specific task goals such as Constraint Induced Movement Therapy (CIMT) and locomotor training [19]. These types of approaches were repetitive and time consuming which may lead to lack of motivation thus may impair the effectiveness of rehabilitation program. Therefore, the need of rehabilitation program that can motivate the patient to finish the rehabilitation program is crucial especially for athlete who needs to return to competition as soon as possible. For that reason, it is crucial to find the appropriate exercise that fun which can motivate the patient and at the same time informative in order to identify the changes or improvement of rehabilitation program towards PFPS. Adding to that, a training regime in PFPS rehabilitation program need to be progressed in a steady way to challenge the patient without inducing fatigue so that they are able to maintain proper motor control [20].

II. Methods

A. Research Design

In order to investigate the effects of Chase Trainer (CT) program on athlete with PFPS a true experimental design which using the modified Pretest-Posttest Control Group method is adopted in this study.

B. Participants

Subjects were volunteered athlete age ranged between 13 and 19 years old who experienced Patellofemoral Pain Syndrome (PFPS) and healthy from Sekolah Sukan Tunku Mahkota Ismail (SSTMI), Bandar Penawar, Kota Tinggi, Johor. The athletes with PFPS were recruited via contact details given by physiotherapist and meet all the inclusion criteria of this study. A total of 27 subjects (22 males and 5 females) were recruited for this study. Although there may be sex differences in response to balance training among PFPS [21] but in athlete population both gender have equal number of risk and symptoms [8]. For generalization, both genders were used as subjects for this study. The mean ± SD for age, weight and height were 14.23 ± 1.31 years, 56.94 ± 9.28 kg, and 164.89 ± 7.85 cm.

The inclusion criteria were set as follows: aged within the range 13 to 19 years old, participated in the inter-state level for at least one year, experienced anterior knee pain surrounding the patella or in the sub-patella region for more than four weeks, insidious onset of symptoms unrelated to a traumatic event, pain from at least two of the following activities commonly associated with PFPS: prolonged sitting, ascending or descending stairs, squatting, kneeling, running, hopping or jumping [2] and identified as Patellofemoral Pain Syndrome (PFPS) patient by qualified physician. Oral and written explanations of the study were offered to the participants. Subjects were excluded if they had one of the following exclusion criteria: Chondromalcia Patella, pain due to palpation along the quadriceps tendon or patellar ligament, medial plica snapping sensation, signs and symptoms of meniscal or articular cartilage pathology, knee joint effusion, history of patellar subluxation or dislocation, history of osteoarthritis, history of neurological impairment, ligament laxity, history of Osgood-Schlatters and history of Sinding-Larsen-Johanson syndrome. It was assumed those patients who suffered from any of the following in the area of joint; tumors, bone infections, traumatic injuries or metabolic disorders are unable to be adjusted if they were given the treatment of PFPS.

Subjects were randomized into either Experiment Group (EG) or Injured Group (IG). Based on subject demographic data, subjects participated actively in three different sports which are soccer (16 subjects), rugby (11 subjects) and hockey (13 subjects). Therefore, their names are listed based on the sports they participated alphabetically and numbered. Subject's name who had been listed as odd number were grouped as Experiment Group (EG) while subject's name been listed as even number were grouped as Injured Group (IG).

C. Testing Protocols

The outcome measures of this study includes 1) Static Postural Control from 1-minute Bilateral Romberg Balance Test with Eyes-open and Eyes-closed condition using computerized Balance Trainer (BT3, HurLab, Tampere, Finland) and 2) Perceived Pain Level which measured from Visual Analogue Scale (VAS) after performing 30 seconds of Step-down Test.

Subjects were asked to perform 1-Minute Bilateral Romberg Test protocol on Triangle Balance Platform with Balance Trainer Software Suite (BT3, HurLab,Tampere, Finland) which consists two condition; a) eyes-open and b) eyes-closed This platform is made from aluminum with 16-bit high precision built-in sensors which can measure up to 200 kilograms weight. For both conditions, subjects need to stand with both feet together where both heels and great toes touch each other (bilateral stance). Subjects were bare foot and not allowed to wear socks while performing this test. Subjects also need to cross both arms and touch opposite shoulder. Subjects were requested to maintain the required position for one minute.

For Eyes-open phase, subjects were required to look straight ahead at the target approximately one meter apart. While for eyes-closed phase, subjects were needed to close their eyes. A countdown of five seconds before and after measurement was verbally announced by the researcher for both phases. Subjects were requested to repeat three sets of both procedures and one minute rest was given between each sets. The average scores of the sway area (C90 Area) for both procedures were used for the analysis.

In terms of perceived pain level, a 100 millimeter Visual Analogue Scale (VAS) was used to measure subject's perceived pain level. This VAS was printed on A4 size paper and given to subject to mark on after performing Step-down Test. In order to identify the Perceived Pain Level, subject need to perform 30 seconds of Step-down Test from eight inches (20.32 centimeter) high platform. Subjects need to step forward and up on the platform followed by step down of the injured leg. The down limb only brush the floor with the heel and then return to full knee extension. These actions were counted as one repetition. The step-down test requires balance and eccentric control of the quadriceps and therefore it suitable to test functional performance of PFPS patients [22]. After 30 seconds of Step-down Test, subject were requested to rate their perceived pain level (PPL) using Visual Analogue Scale (VAS). The VAS incorporates 100 millimeter line marked with 0 indicating no pain and 10 at the other end representing worst possible pain. The subjects were asked to mark on the line along the scale that indicated with their perceived pain level while performing the test. The VAS score was determined by measuring in millimeters from the left hand end of the line to the point that the subject marks.

D.Chase Trainer Program (the intervention)

The Chase Trainer (CT) program only applied to Experiment Group (EG). This training program consists of preprogrammed training modes which include static and dynamic balance activities from Balance Trainer Software Suite (BT3). As mentioned by Zech and colleague (2010), the training duration of six to 12 weeks seem to be more effective when compared with four weeks. In this study the duration of CT training was eight weeks where each session last maximum of one hour. However, all the subjects in experimental group need to complete 16 training sessions with at least two days apart.

The chosen preprogrammed training mode in Balance Trainer Software Suite (BT3) was the Chase Trainer (CT). This CT program required the subject to stand on the BT3 platform and shift their weight based on screen as in Fig. 1. On the screen, the red line indicated subject's centre of pressure (COP) and they need maintained the red line in the ball-shaped blue area as it moves. The ball-shaped blue area moved in axis direction which was anteromedial followed to anterolateral, posterolateral and lastly to posteromedial for the first 30 seconds. Then, the last 30 seconds, the ball-shape blue moved in opposite direction. The score are displayed on the screen as the percentage of time subject spend on the ball-shaped blue area. The difficulty will be adjusted from size and speed of ball-shaped blue area.

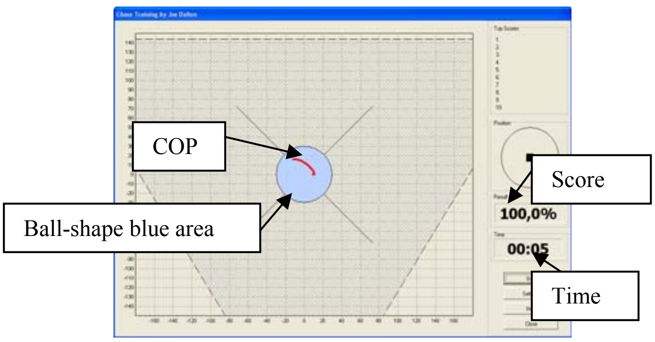

Fig. 1 CT program on computer screen

Subjects were required to complete 16 sessions of maximum one hour of Chase Trainer (CT) program, with two days apart within eight weeks at Makmal Analisis Pergerakan, Sekolah Sukan Tunku Mahkota Ismail, Bandar Penawar, Kota Tinggi, Johor. The training session was conducted from Monday to Thursday at 2p.m. to 5p.m. The training level for Experiment Group (EG) as in Table 1 and each subject need to score at least 70 percents before continue to next level. If the subject unable to score at desired percents, the training program will terminated in order to reduce the risk of injury. For the next session, subject was asked to repeat the sequence of training program from beginning until he/she is able to complete all training level.

TABLE I
CHASE TRAINER (CT) PROGRAM LEVEL OF DIFFICULTY

Level	Direction of blue area	Size of blue area	Speed of blue area	Duration (seconds)
1	Axis	Large	Slow	60
2	Axis	Large	Medium	60
3	Axis	Large	Fast	60
4	Axis	Normal	Slow	60
5	Axis	Normal	Medium	60
6	Axis	Normal	Fast	60
7	Axis	Small	Slow	60
8	Axis	Small	Medium	60
9	Axis	Small	Fast	60

Only Experiment Group (EG) followed the intervention program which was the Chase Trainer (CT) while IG still followed their daily training routine includes training and rehabilitation program with their coach and physiotherapist. As for EG, they need to attend two sessions of CT program per week which consists at maximum time of one hour for duration of eight weeks.

E. Statistical

The results were analyzed using an intention to treat analysis. Baseline characteristics of the intervention and control groups were compared to examine comparability of the two. The effect of exercise on outcome measurements was analyzed using mixed design 3 × 2 group (intervention and control groups) × time (pretest and posttest) analysis of covariance. Baseline values were used as covariates in the analysis of covariance. Statistical significances in Static Postural Control with Eyes-open and Eyes-closed condition and Perceived Pain Level were set at 0.05. Post hoc Bonferroni tests were used to assess which group or time periods showed significant differences. Statistical significance in post hoc Bonferroni tests was also set at 0.05. $P < .05$ was considered statistically significant in analysis of covariance for physical functions. Data were entered and analyzed using SPSS (Windows version 16.0, SPSS, Inc., Chicago, IL).

III. RESULTS

A. Study Population

The initial pool of study subjects comprised 40 athletes who experienced Patellofemoral Pain Syndromes (PFPS) from Sekolah Sukan Tunku Mahkota Ismail (SSTMI), Kota Tinggi, Johor, Malaysia. However, there were two subjects refused to participate and two did not meet the inclusion criteria. The remaining 36 athletes (mean age= 14.75 ±1.17 years, height = 163.14 ± 7.89 cm, weight = 53.31 ± 9.45 kg and Body Mass Index (BMI) = 20.57 ± 1.95) agreed to participate in the study and provided written consent. Among the 36 subjects who took part in this study, only 27 (83.92%) completed the study: 14 subjects in Experiment Group (EG), 13 subjects in Injured Group (IG) The other nine subjects dropped out because attending intensive training and tournament outside the school for more than two weeks during the study. After the imputation of missing data, only 27 subjects were treated for analysis.

B. Baseline Characteristics

Table I summaries baseline data for 27 subjects who completed in this study. No significant differences between the EG and IG were observed in any of the characteristics examined, except in height and weight.

TABLE I
BASELINE CHARACTERISTICS

	EG *n* = 14	IG *n* = 13	p value
Age (years)	15.1 ± 1.3	14.4± 1.2	.167
Height (centimeter)	165.6 ± 4.6	160.7 ± 11.2	.000
Weight (kilogram)	56.1 ± 6.0	54.6 ± 12.9	.036
Body Mass Index	20.4 ± 1.5	20.8 ± 2.4	.089
Duration of symptoms (days)	10.4 ± 5.4	15.0 ± 4.7	.778
Gender (%)			
Male	27.7	19.1	
Female	2.1	8.5	
Type of sports (%)			
Soccer	6.3	6.3	
Rugby	12.7	10.6	
Hockey	10.6	10.6	
Sport participation			
(%)	10.6	8.5	
> 1 year	2.1	17.0	
> 2 years	17.0	2.1	
>3 years			
Training per week			
(%)	8.5	12.8	
>10 hours	2.1	6.4	
>12 hours	10.6	6.4	
>14 hours	8.5	2.1	
>16 hours			
Perceived Pain Level (mm)	54.8 ± 0.8	53.5 ± 1.0	.243
Static Postural Control (mm^{-2})			
Eyes-open	312.7 ± 52.5	313.2 ± 40.2	.069
Eyes-closed	317.7±114.7	387.8±137.3	.556

C. Effects of Intervention

After 8-week on intervention, Perceived Pain Level and Static Postural Control with Eyes-open condition significantly improved (group x time interaction: *p* , 0.05; Table 2). No significant improvements in Static Postural Control with Eyes-closed condition were observed.

TABLE II
PRETEST AND POSTTEST COMPARISON ON CRITERION MEASURES

		EG (n = 14)	IG (n = 13)
Perceived Pain Level	Pre	54.8 ± 0.8	53.5 ± 1.0
	Post	26.3 ± 0.8	47.1 ± 1.5
	Group x time (F value)	22.077*	
	Effect size (η^2)	0.334	
Static Postural Control (Eyes-open)	Pre	312.7 ± 52.5	313.2 ± 40.2
	Post	218.8 ± 81.5	311.3 ± 40.2
	Group x time (F value)	6.113*	
	Effect size (η^2)	0.112	
Static Postural Control (Eyes-closed)	Pre	317.7±114.7	387.8±137.3
	Post	371.4±114.8	387.6±137.3
	Group x time (F value)	0.56	
	Effect size (η^2)	0.001	

*$p < .05$ *F* value; *F* value is a test statistic to decide whether the sample means are within the sampling variability of each other. The null hypothesis is rejected when the *F* value is large. η^2, effect size (η^2) is a measure of the strength of the relationship between the two variables.

IV. DISCUSSION

Our study results provided evidence partially supportive our hypothesis that Chase Trainer (CT) program will improve all criterion measures. However, we found that this intervention be able to decrease perceived pain level and improved static postural control stability with eyes-open significantly. These findings suggest that CT may able to reduce pain and help modify neuromuscular control ability in individual with Patellofemoral Pain Syndrome (PFPS).

Previous studies have reported that most individual with PFPS experienced pain during and after physical activity especially involving weight loading of lower extremities such as walking up/down stair, squatting and sitting [8], [11], [23], [24]. In consequence, the present of pain in knee of PFPS patients has been associated with impairment of proprioceptive acuity in knee joint [25], [26] and impaired the postural control which mainly reflected by increased body sway [27]–[29]. These are some studies that described the link of pain sensation as a crucial element in order to maintain postural control. The results of our study suggest that trained subjects could decrease their postural sway by decreasing the pain sensation through altering their neuromuscular control.

Our study had shown that pain level and static postural control had significantly improved in the Experiment Group (EG). The improvements were observed in perceived pain level after performing Step-down Test and static postural control with eyes-open in quiet standing test which may associate with improved of neuromuscular control after the intervention. Previous researches showed that alteration and adaptation of neuromuscular control may lead to central nervous system reorganization process thus improved functional deficits, such as pain, limited postural control, decreased maximal strength or prolonged muscle reaction time [16], [24], [30]–[32], Therefore, the result of the present study suggested that changes in neuromuscular control are related with changes in perceived pain level thus postural control ability.

Studies have shown that the amount and area of postural sway are often increased during upright stance when visions are restricted [30], [33]. The result found in the current study seems to echo these previous findings (static postural control with eyes-closed) where the amount of sway area were higher compared to eyes-open. Adding to that, this criterion measure did not show significant differences after the intervention. This indicated that, information about motion of the body relative to the environment, neural and musculoskeletal which gained from visions were important in improving postural control [33], [34]. Thus, by lacking this element during the tasks, reorganization process of central nervous system in controlling postural control will be more difficult. If this training incorporates restricted vision, the results might also be change after the intervention.

Not much has been done to define the contribution of neuromuscular control towards pain and how may it related to postural control in Patellofemoral Pain Syndrome patients. Although the change of neuromuscular control strategy has been discussed thoroughly for postural control [30], [35]–[38] but it still not sufficient when it related to pain level. The present study showed decreased perceived pain level and improved postural control ability with eyes-open after intervention, but it still remains unclear from our study how neural adaptation (ie, decrease of pain level) contributes to anatomical and mechanical stability of injured knee with increased of physical activity (Step-down task). Further studies should investigate the effect of decreased pain level after training on functional outcomes other than postural control ability.

This study has several limitations. First, our study examined only perceived pain level at the injured knee and sway area based from different tasks thus provides no information on neuromuscular control strategies for the ankle, knee or hip joint. Second, our data did not measure changes in muscle recruitments which therefore did not enable us to evaluate any possible relationship between muscle coactivation and neuromuscular control. It is a matter of further study to clarify the effect of muscle coactivation with information from multiple joints during the tasks.

V. Conclusion

Our study found that perceived pain level and static postural control especially with Eyes-open condition improved after 8-week of Chase Trainer (CT) program in athletes who experienced Patellofemoral Pain Syndrome (PFPS). This can be associated with improvement of neuromuscular control ability around the injured knee thus it type of exercise may lead to more neuromuscular control ability. Further research is needed to clarify the contribution of improvement in these criterion measures towards neuromuscular control ability and to other functional outcomes such as reduced the injury rate or increased sports performance.

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