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A COMPARISON OF STRENGTH AND STRETCH INTERVENTIONS ON ACTIVE AND PASSIVE RANGES OF MOVEMENT IN DANCERS: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Smith, A, Koutedakis, Y, and Wyon, M. A comparison of strength and stretch interventions on active and passive ranges of movement in dancers: a randomized controlled trial. *J Strength Cond Res* XX(X): 000–000, 2013—The majority of stretching interventional research has focused on the development of a muscle's passive range of movement (PROM). Active range of movement (AROM) refers to the functional range of movement (ROM) available to the participant and provides a better insight into the relationship between muscular antagonistic pairings. The purpose of this study was to assess the effect of 3 strengthening or stretching interventions on hip and lower limb active (AROM) and passive (PROM) ranges of movement. Thirty-nine female dance students (17 ± 0.52 years; 61.7 ± 8.48 kg; 164.4 ± 5.49 cm) volunteered. They were randomly divided into 3 groups, strength training ($n = 11$); low-intensity stretching ($n = 13$); moderate-intensity or high-intensity stretching ($n = 11$). Four dancers withdrew during the study. All groups carried out a 6-week intervention. The strength training group focused on end of range hip flexor strength; the low-intensity and moderate-intensity stretch group carried out a series of stretches at 3/10 and 8/10 perceived exertion, respectively. Active range of movement and PROM were measured preintervention and postintervention using 2-d video analysis. Repeated measures analysis indicated that although all 3 groups improved their PROM during the experimental period (range increase: 9–200 $p < 0.01$), no significant differences were found between the groups. For AROM, both the strength training and the low-intensity stretch groups revealed significant improvements in ROM (range increase: 20–300) compared with the moderate-intensity or high-intensity stretch group ($p < 0.01$). The present

data show that interventions based on strengthening agonist muscles or decreasing the resistance of antagonist muscles through low-intensity stretching are beneficial in the development of both active and passive ranges of movement and provide functional training techniques that are often over looked in favor of the more conservative moderate-intensity stretching programs.

KEY WORDS microstretching, dance, flexibility, développé

INTRODUCTION

Dancers are required to have an extensive range of movement at their joints in order to effortlessly execute demanding choreography (10). Most research in this area has focused on passive range of movement (PROM) (4,6,28,33). However, although this is an important characteristic for all dancers, recent research has shown that active range of movement (AROM) is a better predictor of dance performance especially in the dance genres of classical ballet and contemporary dance (1,32). Even though the ranges of movement seen within dance is significantly greater than most other sports (15,16,18), a number of studies have reported a discrepancy between PROM and AROM in dance populations (14,34,36). A high développé (Figure 1) in dance, the combined actions of hip flexion, external rotation, and abduction, is considered a prerequisite in the world of professional dance (14).

The interventions used to achieve these ranges of movement have included strengthening the hip flexors (i.e., iliopsoas, rectus femoris, sartorius, and tensor fasciae latae) through Pilates (13) and floor conditioning (14), and stretching the antagonist muscles (34), though no studies have compared the different interventions. Anatomically the combination of 3 different muscles (psoas major, psoas minor, and iliacus) have been the focus of several strengthening research projects, given that a relatively weak psoas affects rectus femoris which is considered to be at a mechanical disadvantage at extreme ranges of movement (8,9). Although

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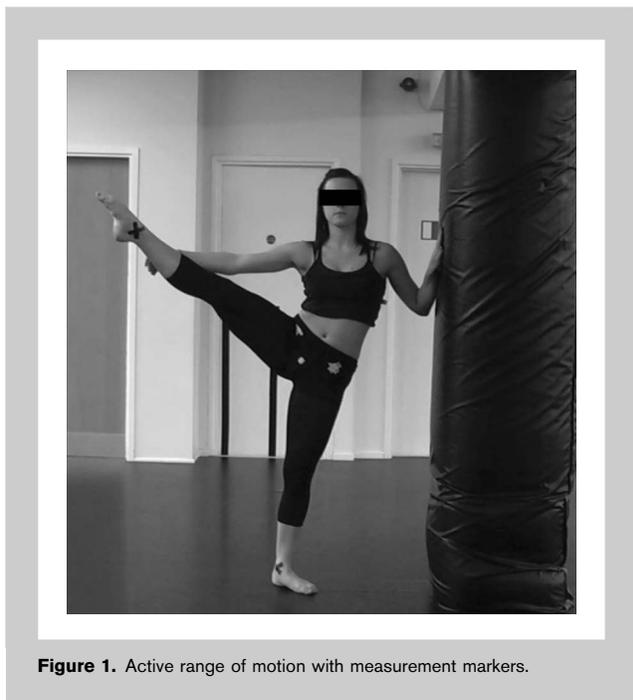


Figure 1. Active range of motion with measurement markers.



Figure 2. Passive range of motion with measurement markers.

the strongest of the hip flexors, reduced psoas strength could be due to inability to exert maximal force at the end ranges of muscle contraction thereby limiting the AROM (14).

Wyon et al. (36) noted the effect leg length has on AROM, where dancers with longer legs had lower développés possibly highlighting the lack of strength within the hip flexors to overcome the increased load of the longer leg. Active range of movement could also be limited due to increased parasympathetic activity and/or the internal resistance of the antagonist muscle (collagen, actin-myosin complex) (2). If the latter muscle group is unable to relax sufficiently, even with reciprocal inhibition, then the hip flexors have to exert additional force to not only overcome the weight of the leg but also resistance of the hip extensors. Furthermore, Apostolopoulos (3) hypothesized that high intensity stretching routines can result in adaptations occurring at the musculotendon part rather than in the main belly of the muscle; whereas other studies have suggested the increase in range

of movement (ROM) is due to an increased pain tolerance (5,20,21). Therefore, the utilization of lower intensity stretching exercises would cause reduced parasympathetic activity, thus allowing adaptation to occur within the muscle itself. In doing so, the muscle would offer less resistance when it is being stretched by the contraction of its agonist muscle. A recent set of data demonstrated an AROM increase after a low-intensity stretch intervention (34).

The purpose of this study was to examine whether the predominantly used mid-high-intensity stretching is the best method of increasing lower limb active (AROM) and passive (PROM) ranges of movement compared with low-intensity stretching and end-of-range strength training interventions.

METHODS

Experimental Approach to the Problem

This study was designed to compare three 6-week intervention strategies on changes in passive and active ranges of motion.

A randomized controlled design was selected with subjects assigned in one of 3 groups via a closed envelope randomized selection process. Two of the interventions, strengthening (14) and low-intensity stretching (34), have been studied in the past but not in relationship to more traditional dance stretching intensities (moderate/high intensity). The strength group utilized a known hip flexor

TABLE 1. Subject characteristics.

Group	No.	Age (yrs)	Mass (kg)	Height (cm)
Strength conditioning	11	17 + 0.49	66.9 + 6.83	165.9 + 4.04
Low-intensity stretch	13	17 + 0.56	57.8 + 7.61	163.2 + 6.31
Moderate-intensity or high-intensity stretch	11	17 + 0.56	62.1 + 8.64	164.7 + 7.52
Total	35	17 + 0.52	61.7 + 8.48	164.4 + 5.49

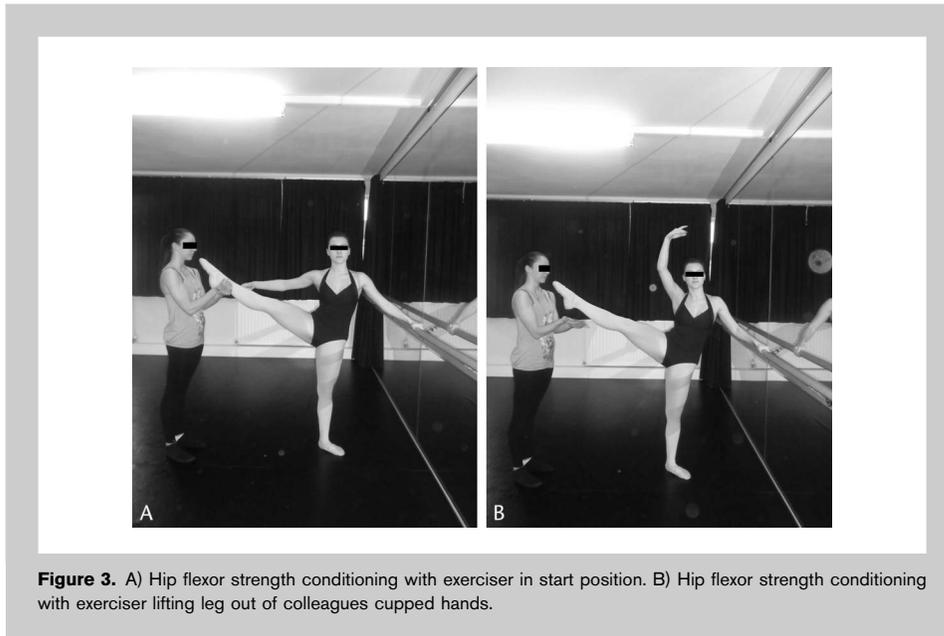


Figure 3. A) Hip flexor strength conditioning with exerciser in start position. B) Hip flexor strength conditioning with exerciser lifting leg out of colleagues cupped hands.

strength training protocol adapted from Grossman and Wilmerding (14) as did the low-intensity stretch (3/10 intensity) group (34), whereas the other stretch group (control) carried out their passive stretches at the higher intensity (8/10). Active range of movement and PROM were measured in the sagittal plane before and after the 6-week interventions utilizing a développ e seconde for AROM.

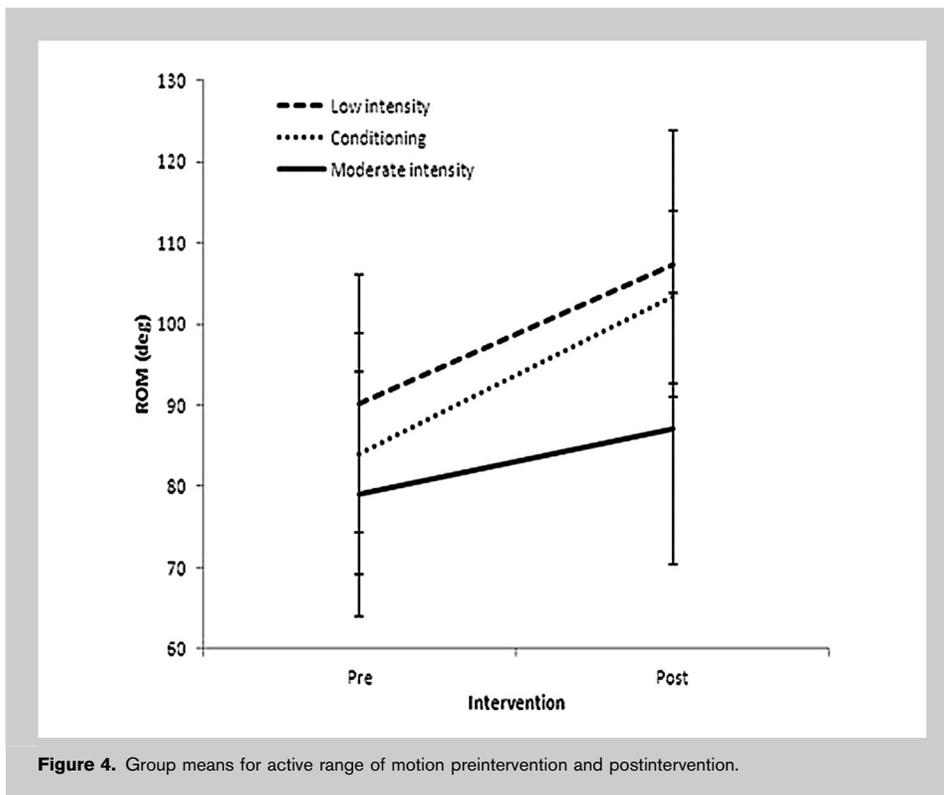


Figure 4. Group means for active range of motion preintervention and postintervention.

Subjects

The total of 39 moderately trained female dance students between 16 and 18 years of age volunteered for the study though 4 dancers dropped out and their data have been excluded (Table 1). They were engaged in approximately 15 hours of technique class a week. On approval from the dance college, the students were fully briefed as to the requirements and processes of the study, and each subject signed informed consent before their commencement of the study. Ethical approval for the study was given by the University of Wolverhampton ethics committee.

Procedures

The participants active and passive ranges of motion were assessed preintervention and postintervention for each leg, these occurred on the same day of the week after the first class of the morning (ballet). The previous days' activities and preceding nights' sleep quantity was controlled as much as possible and did not vary more than 1 hour for activity or sleep between the pretest and posttest days, each participant were also asked to have a similar breakfast the morning of the test. Each dancer carried out a 10-minute general warm-up that included cardiovascular exercise and a series of lower limb stretches (gluteal, hamstring, quadricep, and calf muscles) before markers being placed on their pubis and medial malleolus. They were then filmed carrying out three maximal trials of AROM and PROM (Figure 2, PROM; and Figure 1, AROM), on each leg with a digital video camera (Panasonic HDC-HS900) as previously used (34). Verbal positioning cues were provided by experienced dance teachers to make sure that correct posture was maintained, these included pelvis and spine alignment and plane of movement of testing leg.

The subjects were randomly assigned to one of 3 following groups: strength conditioning,

TABLE 2. Mean prerange and postrange of movement for all groups.

Group	Leg	Passive ROM		Active ROM	
		Pre	Post	Pre	Post
Strength conditioning	R	132 ± 12.19	150 ± 11.81†	84 ± 13.27	105 ± 16.28†
	L	128 ± 14.97	147 ± 11.62†	84 ± 17.87	103 ± 12.92†
Low-intensity stretching	R	134 ± 12.53	148 ± 14.66†	92 ± 17.25	112 ± 16.28†
	L	133 ± 17.85	144 ± 22.50†	89 ± 14.63	105 ± 14.12†
Moderate-intensity or high-intensity stretching	R	132 ± 12.74	141 ± 6.72†	76 ± 14.92	88 ± 12.12
	L	123 ± 16.50	133 ± 15.97†	79 ± 12.52	81 ± 14.52

AU9 *Indicates significant differences ($P < 0.05$).
 †Indicates significant differences ($P < 0.01$).
 ROM, range of movement.

low-intensity stretching, and moderate-intensity or high-intensity stretching. The strength conditioning dancers focused on their hip flexor muscle group, although also engaging their stance leg and core. They used the end-of-range strength training by working at the last 10° of AROM. This was achieved by the dancer carrying out maximal AROM and a partner supporting her leg at this position. The exercising dancer then lifted the leg up as high as possible, away of the partner's hand, using the hip flexor complex, although trying to keep their hips horizontal. This was held

for 3 seconds before relaxing and allowing their partner to take the weight of the active leg once more. They performed 3 sets of 5 lifts on each leg increasing to 10 lifts on each leg throughout the duration of the 6 weeks (Figures 3A, B).

The low-intensity group carried out a lower limb stretching programme 5 times a week focusing on the gluteal, hamstring, quadriceps, and calf muscles. Participants were told to perform their prescribed stretches according to the guidelines outlined by Apostolopolous (2,34), which included holding each stretch at an intensity of 3/10 RPE for 1 minute. The categorization of

3 or 4 of 10 is based on a perception scale of intensity of stretching. According to this qualitative scale, 0 represents no stretch whereas 10 is equivalent to an aggressive stretch, associated with pain and discomfort, often described as a burning sensation. Apostolopolous, on his website, describes the sensation as similar to "putting your hand in warm water". The dancers in the moderate-intensity or high-intensity group were asked to continue with their normal stretching regimen throughout the process at an intensity of 8/10 RPE and 60-second duration using the same muscles as the low-intensity group. Participants were given no additional information on stretches, duration, frequency, or ideal times to stretch.

Data and Statistical Analysis

The Dartfish video analysis software (Fribourg, Switzerland)

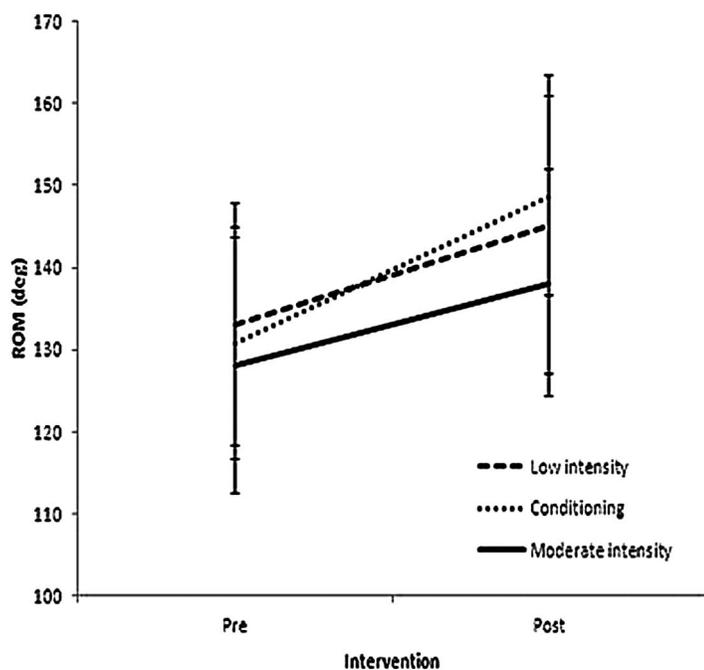


Figure 5. Group means for passive range of motion preintervention and postintervention.

were used to analyze the dancers' lower limb range of motion by calculating the angle between the markers on the malleoli of the stance and active legs and the pubis. The greatest range of movement for each leg and ROM was recorded for analysis. A 3×2 factorial analysis of variance (ANOVA) (3 interventions \times pre-post tests) with Scheffé post hoc test was conducted on the AROM and PROM data with the significance set at $p < 0.05$.

RESULTS

Factorial ANOVA analysis indicates a significant increase in PROM for all 3 groups ($F_{1142} = 28.411$; $p < 0.01$) with no significant differences between groups (Figure 4). PROM increases ranged between 7%–13%, though it was the conditioning group that had the greatest percentage change. No bilateral differences were noted (Table 2).

A significant increase in the AROM ($F_{1142} = 34.286$; $p < 0.01$) was noted between the groups with post hoc tests indicating significant improvements ($p < 0.01$) achieved by the dancers involved in the low-intensity stretch and strength conditioning groups (Figure 5) compared with their counterparts in the moderate-intensity or high-intensity stretch group ($p > 0.05$). The strength conditioning group demonstrated the highest increase of 23%, whereas the increases for the low-intensity and moderate-intensity or high-intensity groups were 19% and 10%, respectively.

DISCUSSION

The purpose of this study was to compare three 6-week intervention strategies on changes in AROM and PROM in a dance population. It was found that AROM was positively affected by both the strength and low-intensity stretch training compared with the moderate-intensity or high-intensity stretch. These findings are in line with published reports which stressed the benefits of strength conditioning (14) and low-intensity stretching (34) on improving lower-limb AROM; the strength group experienced the greatest percentage increase. PROM also significantly improved in all 3 groups with the conditioning group demonstrating a greater increase than the 2 stretching interventions (Figure 4).

The observed significant changes, as a result of the conditioning intervention, may partly be due to the direct strengthening of the agonist muscles and second due to the training of reciprocal inhibition of the antagonist muscles (11). The later has an effect on the AROM by allowing the antagonist muscles to relax thereby reducing the force needed by the agonists to overcome the internal resistance of the antagonist muscles, as previously noted in activities such as running and walking (17); these benefits may also be carried over to PROM (23). Resistance training has also been shown to have a positive effect on flexibility with both resistance and vibration training interventions reporting improvements in passive and active ranges of movement, respectively (12,29,35). Indeed, it has been reported that strength training has a myogenic response whereby an increased muscle

fascicle length can be achieved by augmenting the number of sarcomeres in series (26). Furthermore, the end of AROM training movements utilized within this training intervention mimic the AROM test by targeting the iliopsoas complex (27) that allows the dancer to learn to engage the correct muscles within the hip in co-ordination with the core and the support leg, rather than isolating the hip complex (14) or using full range of movement exercise (29) as in previous studies. It should also be stressed that the adopted strength training protocol involved a considerable element of eccentric muscle action, due to the effects of gravity, and that training with eccentric exercise can lead to greater muscular strength improvements compared with other form of muscle conditioning (25).

Stretching is used to modify muscle length and to avoid debilitating events such as muscle damage, which may lead to decline in muscle performance (24). It has been reported that both static stretching and proprioceptive neuromuscular facilitation training are effective in attenuating muscle damage and that flexible muscles are less susceptible to the damage (7). It has been further suggested that the milder symptoms of exercise-induced muscle damage in children compared with adults include greater muscular flexibility leading to less over-extension of sarcomeres during exercise (22).

The current low-intensity stretching intervention was based on microStretching theory by Apostolopoulos (2,3). The theory advocates that low-intensity stretching causes adaptation by reducing the activation of the parasympathetic nervous system that reduces excess tension in the execution of movements, lessening resistance in the extended muscles. This would account for the observed improvements in both the AROM and PROM in this study. In general, appropriate muscular stretching and the associated flexibility is important as it helps to accommodate the changes in cell geometry that occur during contraction (31).

The observed changes in the moderate-intensity or high-intensity stretch group are concurrent with previous research on adaptations in PROM (2,4,10,28) with the intervention either causing reduction in the muscle's passive tension by instigating adaptations within the muscles myofibrils (19) or by increasing the tolerance to pain during the stretch (5,20,21). The lower improvements in AROM are potentially due to passive stretching not causing adaptations in the parasympathetic system as highlighted by Apostolopoulos (3); therefore, during active ROM, the antagonist muscles are still providing tension against the agonist activity.

Functional range of movement is an integral aspect of dance performance and has been related positively to improved dance artistry (1,10,30,32). The present study indicated that low-intensity stretching and end-of-range strength training produces significant improvements in AROM and PROM. The underlying theory of low-intensity stretching is that it causes adaptation by reducing the activation of the parasympathetic nervous system that reduces excess tension in the execution of movements, lessening resistance in the

extended muscles. End-of-range resistant training adaptations are twofold with improved reciprocal inhibition coupled with improved strength results. The techniques employed in this study (Figures 3A, B) have the added benefit of training the core and stance leg making the exercise more functional than previously reported interventions. The present study has shown that 6-week end of range targeted resistance training, low-intensity, and moderate-intensity or high-intensity stretching all have significant increases in PROM. We also found significant improvements in AROM for the low-intensity and end-of-range resistance training with the later having the greater increases. This study highlights the advantages of less used localized strength training and low-intensity stretch training as intervention strategies on improving range of movement, especially functional AROM.

PRACTICAL APPLICATIONS

The data collected in this study indicated that the less traditionally used interventions of targeted strength training and low-intensity stretching are superior at increasing active and passive ranges of movement than the more normal moderate-intensity or high-intensity stretch. Overall microStretching or low-intensity (3/10 intensity) stretching has the greatest effects on both passive and active ROM. The combined increases in AROM and PROM were greater than the moderate-intensity or high-intensity stretch and the end of range strength interventions.

Therefore, dance instructors and coaches should incorporate microStretching and end-of-range resistance training within their schedules. microStretching should be used as an “end-of-day” recovery session; the position of the stretches is very important, as in order to effectively stretch a muscle you need to eliminate the potential of a muscle contraction; therefore, placing the body in a stable position where the muscle can be stretched without extraneous tension is vital. The technique should be programmed posttraining with each stretch being held for 60 seconds at an intensity of 3/10.

The targeted end-of-range resistance training is beneficial for dancers that have a large PROM (grande battement) but a limited AROM (développé). By using the suggested intervention of working in centre with a partner not only are the agonist muscles developed, thereby increasing the height of the développé, but also the stabilizing muscles of the core and the supporting muscles. This makes the training much more functional than similar exercises at the barre or on the floor. These exercises can be carried out as part of a technique class but will produce local muscular fatigue and therefore their incorporation needs to be considered in context with the class’s overall goals.

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