

Hip and ankle range of motion and hip muscle strength in young novice female ballet dancers and controls

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Abstract

Objectives—To compare the hip and ankle range of motion and hip muscle strength in 8–11 year old novice female ballet dancers and controls.

Methods—Subjects were 77 dancers and 49 controls (mean (SD) age 9.6 (0.8) and 9.6 (0.7) years respectively). Supine right active hip external rotation (ER) and internal rotation (IR) were measured using an inclinometer. A turnout protractor was used to assess standing active turnout range. The measure of ER achieved from below the hip during turnout (non-hip ER) was calculated by subtracting hip ER range from turnout range, and hip ER:IR was derived by dividing ER range by IR range. Range of right weight bearing ankle dorsiflexion was measured in a standing lunge using two methods: the distance from the foot to the wall (in centimetres) and the angle of the shank to the vertical via an inclinometer (in degrees). Right calf muscle range was measured in weight bearing using an inclinometer. A manual muscle tester was used to assess right isometric hip flexor, internal rotator, external rotator, abductor, and adductor strength.

Results—Dancers had less ER ($p < 0.05$) and IR ($p < 0.01$) range than controls but greater ER:IR ($p < 0.01$). Although there was no difference in turnout between groups, the dancers had greater non-hip ER. Dancers had greater range of ankle dorsiflexion than controls, measured in both centimetres ($p < 0.01$) and degrees ($p < 0.05$), but similar calf muscle range. After controlling for body weight, controls had stronger hip muscles than dancers except for hip abductor strength which was similar. Regression analyses disclosed a moderate relation between turnout and hip ER ($r = 0.40$). There were no significant correlations between range of motion and training years and weekly training hours.

Conclusions—Longitudinal follow up will assist in determining whether or not hip and ankle range in young dancers is genetically fixed and unable to be improved with further balletic training.

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A successful career in classical ballet demands that the dancer be both flexible and strong. The essential movements in ballet are plié and turnout. These movements are the foundation from which many other movements, such as leaps and jumps, occur. Plié requires the weight bearing ankle to be dorsiflexed while the upright torso is lowered over flexed hips and knees and maximally externally rotated legs.¹ The heels remain on the ground as the body is lowered in demi-plié. In grand-plié, the heels are raised and the body is lowered to such a degree that the thighs become parallel to the ground. Thus correct plié requires extreme ankle dorsiflexion and hip external rotation (ER).

Turnout is the term used to describe ER of both legs so that the feet are rotated 180° from each other.² The five basic classical balletic positions are based on this turned out posture. Full turnout requires an extraordinary range of hip ER.³ The degree of turnout is determined by muscle strength, soft tissue extensibility, and skeletal anatomy.^{4,5} As excellent turnout is one of the critical traits required for a dancer to succeed, many dancers with insufficient hip ER attempt to increase turnout by obtaining additional movement at other joints. A technique commonly used is to place the feet in 180° of turnout with the hips and knees flexed, and then force the hips and knees into extension without moving the feet, a technique known in balletic circles as “screwing the knee”.³ The resulting compensatory movements that occur at anatomic sites other than the hip joint may predispose the dancer to various acute and chronic injuries, particularly at the tibiofemoral and patellofemoral joints.⁶⁻⁸

Classical ballet also demands sufficient muscle strength.⁹ Lower extremity strength is not only essential for the performance of explosive manoeuvres, such as leaps and jumps, but is vital for the balance and postural control in various balletic positions, such as arabesque and attitude.

Previous cross sectional studies have found that, compared with controls, ballet dancers had significantly greater turnout angles¹⁰ and hip ER,^{7,10-12} but lesser hip internal rotation (IR).^{7,10,11} It has been suggested that this increase in hip ER at the expense of IR may reflect an altered axis of hip rotation.^{10,13} Some of these studies, however, did not clearly document measurement protocols, instrumentation, or method of statistical analysis. In addition, these studies focused on the range of motion in elite junior (full time ballet school students) and

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Table 1 Characteristics of young novice dancers (n=77)

Characteristics	Mean (SD)
Age commenced dancing classes (years)	4.3 (1.4)
Total years of dancing classes	5.3 (1.4)
Hours/week danced in last 6 months	4.6 (2)
Classical	2.7 (1.4)
Tap	0.4 (0.6)
Character	0.3 (0.9)
Modern	0.9 (0.9)
Other	0.3 (0.7)
Started pointe*	3 (3.9)
Grade/level†	2 (2)

*Given as number (%).

†Given as median (interquartile range).

professional ballet dancers and not young novice dancers. It is not apparent whether the different flexibility patterns in ballet dancers reflect a selection process, whereby genetically more flexible individuals become elite or professional dancers, or whether the increased hip ER is acquired with balletic training.

There are very few published data on the strength characteristics of classical ballet dancers. Micheli *et al.*¹² found female professional dancers (mean age 27 years) to have strong lower extremities (quadriceps, hamstrings, dorsiflexors, and plantarflexors) and relatively weak upper extremities (elbow flexors and extensors). However, the authors did not report measurement procedures, and the findings were not compared with non-dancer controls or other female athletic groups. Kirkendall and Calabrese⁹ reported that, at peak season, the mean quadriceps strength in female ballet dancers was around 70% of the weight-predicted normal for athletes, with female dancer strength being the lowest among the athletic groups reviewed. These studies paid little attention to the strength of hip flexors, abductors, adductors, and rotators, muscles that are vital for postural control and execution of movement in classical ballet.⁸

The aim of this cross sectional study was to compare the hip and ankle range of motion and hip muscle strength in 8–11 year old novice female ballet dancers with age matched controls. This will allow us to identify whether patterns seen in older more elite dancers are present at an early age before intensive ballet training occurs.

Materials and methods

SUBJECTS

Seventy seven female ballet dancers aged 8.0 to 11.1 years were recruited from 35 classical ballet schools throughout Melbourne, Australia. Letters were sent to the ballet schools, and telephone contact was made with the parents/guardians of potential subjects. The dancers participated in a wide range of weekly hours of ballet training (1 to 10 hours), with an average of 4.7 hours per week. Table 1 presents descriptive data on their dance history.

The control cohort consisted of 49 non-dancing girls aged 8.2 to 11.1 years, recruited from 63 metropolitan primary schools in Melbourne, Australia. The controls were matched for age and residential postcode to obtain similar socioeconomic distributions between the groups. Letters were sent to the principals of

Table 2 Descriptive statistics for young novice dancers and controls

Characteristics	Dancers n=77	Controls n=49
Age (years)	9.6 (0.8)	9.6 (0.7)
Height (cm)	136.4 (6.7)	138.9 (7.4)
Weight (kg)	30.5 (5.4)*	35.5 (8.2)
BMI	16.3 (2.1)*	18.3 (3.2)
Hours/week sport	0.63 (1.40)	0.56 (0.89)

Results are expressed as mean (SD).

BMI, body mass index (weight/height²).

*Significantly different from controls, p<0.01.

271 primary schools requesting participation of their students in the study. If they agreed, the principals sent letters outlining the study to parents/guardians who then contacted the investigators directly if they agreed to participate. Initial eligibility of subjects according to the selection criteria was assessed at this stage.

To be included in the study, all dancers and controls had to be prepubertal or peripubertal, that is Tanner breast stage 1 or 2.¹⁴ Controls were excluded from the study if they participated in more than two hours a week of extracurricular organised sporting activities (not including swimming) or if they had participated in more than three months of balletic or gymnastic training.

Table 2 summarises descriptive data on both dancers and controls. The groups did not differ in terms of age, height, and weekly hours of extracurricular sport. However, the control subjects had a significantly higher body mass index and were significantly heavier than the dancers (both p<0.01).

The study was approved by the human research ethics committee of the University of Melbourne and the Royal Melbourne Hospital Board of Medical Research. Written informed consent was provided by the parents/guardians of all subjects.

MEASUREMENT PROTOCOLS

Right sided active hip ER and IR range, turnout angle, ankle dorsiflexion range, calf muscle range, and hip muscle strength were measured in all dancers and controls by one of four raters, all specifically trained in the measurement procedures. The same rater tested all variables in the same subject. The procedures for measuring hip ER and IR, turnout, and ankle dorsiflexion (degrees) are slightly modified versions of those used by Khan *et al.*¹⁰ in elite junior dancers and by Bennell *et al.*¹⁵ No warm up was performed before testing, although practice trials were given for each test.

Active hip ER and IR range

An inclinometer (Isomed, Portland, Oregon, USA) was used to measure range of active hip ER and IR in the right hip. Subjects were positioned supine on a standard treatment table. The right thigh was stabilised in a 12.5 cm U tube with velcro straps, and the lower leg hung freely over the end of the table, bending at the knee. The left foot rested on the examination table next to the right thigh to allow room for testing. For the measurement of active hip ER range, the long axis of the inclinometer was placed along the anterolateral margin of the



Figure 1 Set up position for the measurement of active hip external and internal rotation range of motion.

tibia, 12 cm below the tibial tuberosity. Subjects were asked to perform maximal active hip ER and the angle from vertical was measured to the nearest degree. To measure active hip IR range, subjects were asked to perform maximal active hip IR from the starting position previously described. Subjects were instructed in how to perform the actions, and after two practices, they performed each movement (ER and IR) three times (fig 1). All measurements were recorded and the median of the three was used for analysis.

Standing active turnout in first position

A specially constructed turnout protractor was used to measure the range of motion obtained in the turnout position.¹⁰ The turnout protractor displayed rays from 10° to 100° marked in 1° intervals on each side of the central spine. Subjects began by standing on the device with their heels locked against the 5 cm central spine, held firmly against the heel plates of the turnout board. Feet were parallel, together, and facing forward. The space between the second and third toes was used as a landmark. Subjects were asked to adopt a position of maximal bilateral turnout in one sweep, with the movement coming from the hips (fig 2). To quantify turnout, the difference between the angle of the foot in the neutral position and the angle in the turned out position was measured on both the right and left sides. All measurements were recorded and the median of five attempts was used for statistical analysis.

Ankle passive dorsiflexion range (standing plié in parallel)

To measure the range of weight bearing passive ankle dorsiflexion on the right, subjects stood facing a wall, in a step-stance position with the feet approximately shoulder width apart. A board with a ruler attachment was placed on the floor against the wall, and a 15° wedge was positioned against the board. The subject's right foot was positioned in front of the left, on the wedge to standardise the amount of supination/pronation. The medial aspect of the foot was aligned with the upper border of the wedge and the tip of the second toe was placed on a line in the middle of the wedge. Subjects were instructed to lunge forward by approximating the front knee (right) with the wall and



Figure 2 Measurement of standing active turnout in first position.

keeping the right heel flat. They were allowed to hold on to the wall for balance. The wedge was gradually moved away from the wall until the maximum distance that the subject could lunge and still touch the wall with the front knee was reached. To measure the range of dorsiflexion in degrees, the long axis of the inclinometer was aligned with the midline of the right Achilles tendon. The angle (of the shank from the vertical) was read from the inclinometer to the nearest degree and recorded. For the measurement of right ankle dorsiflexion in centimetres, the distance between the end of the right big toe and the wall was measured to the nearest 0.1 cm using the ruler attached to the board on the floor (fig 3). Each method was used to test dorsiflexion three times with subjects resuming a comfortable position between each trial. All results were recorded and the median of the three was used for data analysis.

The reliability of the procedures for measuring supine hip ER and IR, standing turnout range, and ankle dorsiflexion (degrees) has been evaluated previously.¹⁰⁻¹⁵ Pearson *r* values ranged from 0.77 to 0.96 for test-retest reliability and from 0.82 to 0.99 for intertester reliability.

Calf muscle range

Right calf muscle range was measured with subjects standing, facing a wall in the step-stance position. The right foot was placed behind the left. Holding on to the wall for balance, subjects performed a forward lunge by bending the front (left) knee towards the wall



Figure 3 Measurement of passive ankle dorsiflexion in weight bearing.



Figure 4 Measurement of calf muscle range.

and keeping the right knee extended and the right heel flat, in order to stretch the right calf muscle. The angle (between the shank and the vertical) reached was measured with an inclinometer placed on the central long axis of the Achilles tendon (fig 4). This was performed three times with subjects allowed to resume a comfortable position between trials. Results were recorded and the median used for analysis.

Hip muscle strength measurements

A Nicholas manual muscle tester (NMMT) (Lafayette, Indiana, USA) was used to measure isometric hip strength. This device has been found to be reliable in measuring muscle strength in elementary school aged children.¹⁶ For all measurements, the tester placed the NMMT on the subject's limb and applied a gradual force over one second, with the subject manually resisting the force. The tester then applied additional force until the muscle contraction broke and the limb began to move. The tests were carried out three times, with subjects resting for 10 seconds between trials. All results were recorded and the maximum peak force reading used for statistical analysis.

Hip flexors

For the measurement of right hip flexor strength, the subject sat on the edge of a standard treatment table with both lower legs hanging freely over the edge. The tester stood directly in front of the subject. The subject was asked to lift her right thigh 10 cm off the table, and the NMMT was placed on the top of the thigh, just proximal to the superior pole of the patella.

Hip rotators

The subject was positioned supine on the treatment table for the measurement of right hip external rotator and internal rotator strength. Both knees were flexed to allow the lower legs to hang over the edge of the table. To

measure right hip external rotator strength, the NMMT was placed on the medial border of the lower leg, just proximal to the right medial malleolus. For the measurement of right hip internal rotator strength, the NMMT was placed just proximal to the right lateral malleolus on the lateral border of the right lower leg.

Hip abductors and adductors

To measure right hip abductor and adductor strength, the subject was positioned supine on the table, with both knees fully extended. The NMMT was placed on the lateral border of the right lower leg, just proximal to the right lateral malleolus, for the measurement of right hip abductor strength. To measure right hip adductor strength, the NMMT was placed on the medial border of the right lower limb, just proximal to the medial malleolus.

STATISTICAL ANALYSIS

Data from dancers and controls were normally distributed. Both descriptive and range of motion data were compared between groups using independent *t* tests. To compare hip muscle strength between dancers and controls, a one way analysis of covariance was used with body weight as a covariate. Regression analysis was used to investigate the relation between turnout angle and active hip ER range as well as the relations between range of motion and years of balletic training and weekly hours of training in the last six months.

Results

Tables 3 and 4 present results for hip and ankle range of motion and hip muscle strength respectively in dancers and controls. Controls had significantly greater hip ER ($p < 0.05$) and IR ($p < 0.01$) range of motion than the dancers. However, the groups did not differ with respect to turnout. The measure of ER achieved from joints other than the hip during right turnout (non-hip ER), calculated by subtracting the

Table 3 Range of motion in young novice dancers and controls

Movement	Dancers	Controls
Hip rotation		
External rotation (degrees)	32.3 (12.5)*	37.4 (10.3)
Internal rotation (degrees)	26.7 (14.4)**	35.3 (8.5)
External rotation:internal rotation	1.5 (0.9)**	1.1 (0.4)
Non-hip external rotation (degrees)	18.4 (13.4)*	13.1 (10.4)
Turnout (degrees)		
Right	46.2 (9.8)	47.5 (8.9)
Left	46.7 (9.2)	47.5 (8.7)
Total	92.9 (18.3)	95.0 (16.0)
Ankle dorsiflexion		
Centimetres	6.4 (2.8)**	3.8 (2.2)
Degrees	31.9 (6.8)*	29.2 (6.4)
Calf range (degrees)	25.0 (7.6)	25.4 (8.5)

Results are expressed as mean (SD).

Significant difference from controls is indicated: * $p < 0.05$; ** $p < 0.01$.

Table 4 Strength in young novice dancers and controls

Muscle group	Dancers	Controls
Hip flexors	8.5 (2.2)*	9.9 (2.1)
Hip external rotators	2.8 (1.0)**	4.0 (1.3)
Hip internal rotators	3.0 (1.6)**	4.4 (1.3)
Hip abductors	4.5 (1.4)	5.2 (1.9)
Hip adductors	4.2 (1.6)**	5.5 (0.1)

Results are expressed in kg and are mean (SD).

Statistical tests were performed using one way analysis of covariance with body weight as a covariate: significantly different from controls, * $p < 0.05$, ** $p < 0.01$.

right hip ER from the right turnout angle, was significantly greater in the dancers ($p < 0.05$). The amount of right non-hip ER as a percentage of right hip ER range was 40% in the dancers and 27% in the controls. Dancers had significantly greater right ankle dorsiflexion range, in both centimetres ($p < 0.01$) and degrees ($p < 0.05$). No difference in calf muscle range was found. Dancers had significantly less strength in hip flexors ($p < 0.05$), internal and external rotators ($p < 0.01$), and adductors ($p < 0.05$) than controls. However, the groups did not differ in hip abductor strength.

Regression analysis disclosed a moderate relation between range of right hip ER and turnout ($r = 0.40$ and 0.43 for right turnout and total turnout respectively). Within dancers, there were weak non-significant correlations between years of balletic training and range of hip ER ($r = -0.12$), hip IR ($r = -0.09$), turnout ($r = -0.05$), and ankle dorsiflexion ($r = 0.05$). The relations between weekly hours of balletic training and hip ER range ($r = -0.10$), hip IR range ($r = -0.13$), turnout ($r = 0.01$), and ankle dorsiflexion ($r = 0.15$) were also weak.

Discussion

In this discussion we use the term “young novice” to refer to dancers in the present study and “elite junior” for full time ballet school students aged around 16–18 years. The term “professional” refers to full time professional dancers.

Are ballet dancers born or made? Our study cannot answer this question, but as it provides the first data for young novice female dancers it supplies some key circumstantial evidence. Furthermore, the method of data collection permits us to compare our data with those obtained in elite junior dancers.¹⁰

HIP ROTATION RANGE

Our results show that these 8–11 year old dancers had statistically less hip ER range of motion than age matched controls. However, the mean difference was only 5° , an amount that could be biologically trivial and may be partly explained by measurement error. Furthermore, range of motion was tested actively and hence may be influenced by joint and soft tissue tightness as well as by muscle strength. As the result of having relatively weaker hip external rotator muscles, the dancers may have been unable to match the amount of active hip ER achieved by the stronger controls. Assessment of passive hip joint range of motion would shed light on the nature of the limiting factors.

Turnout is a measure of the combined range of hip ER and non-hip ER. The latter reflects ER achieved at the knee, ankle, and tarsal joints. Our data suggest that, although young novice dancers as a group have lesser hip ER than controls, they compensate by having greater non-hip ER than controls. High levels of non-hip ER are a risk factor for injury, as the mechanism known in ballet circles as “screwing” the leg is believed to produce large torsional forces on the medial aspects of the knee, shin, ankle, and foot.¹⁷

The results of our study suggest that pre- and peri-pubertal novice ballet dancers are not blessed with the much greater range of hip ER and turnout seen in elite dancers. This suggests that the greater range of motion seen in both hip ER and turnout in older dancers^{7 10–12} must arise as a result of training or selection (only those dancers with greater range of motion become professional dancers) or perhaps a combination of both factors. We found no association between years of ballet training and range of ER in these novices, some of whom had already been in ballet training for up to 10 years, albeit most at a low level. While this provides circumstantial evidence that ballet turnout is inherent in some girls, and not achieved with the type of training young dancers undertake, a longitudinal follow up of a cohort of girls would provide more definitive data to answer that question.

Novice dancers had reduced range of IR compared with controls, consistent with the pattern seen in elite junior and professional dancers.^{7 10 11 12} Reduced active range of hip IR can be due to femoral neck anteversion, soft tissue tightness, or muscle weakness. It appears unlikely that the femoral neck anatomy explains the reduced IR as it would also result in increased ER which was not found to be the case. Soft tissue tightness can result from failure to use a joint through full range of motion and this can develop within months. This mechanism may explain the finding of reduced IR in the present study. Reid *et al*⁷ considered dancers’ avoidance of using full hip IR and subsequent shortening of the hip external rotators to be the root of lateral knee pain in elite junior dancers. Similar to our findings on ER and training, there was no association between hip IR and years of ballet training or weekly hours of ballet training in the dancers.

ANKLE DORSIFLEXION RANGE OF MOTION AND CALF MUSCLE RANGE

We found that dancers had significantly greater ankle dorsiflexion than controls by both methods used to measure it. Dancers had 25% greater dorsiflexion than controls when measured in centimetres (distance from wall) and 12% greater when measured in degrees (inclinometer). Also of interest was the finding that calf length, a measure of muscle flexibility, did not differ between the groups. Ankle dorsiflexion, on the other hand, is less a measure of flexibility per se as it is limited by capsular tightness and skeletal configuration of the ankle joint as well as by soleus flexibility.

Using equipment and methodology identical with that used in another study on elite junior dancers, we found that the absolute values of ankle dorsiflexion in novices was only 2° less than that reported for their elite counterparts¹⁰ who had received five to eight years more ballet training. This suggests that ballet training does not enhance passive ankle dorsiflexion. This contention is strengthened when one notes that elite junior dancers have no greater ankle dorsiflexion than physically active non-dancers.¹⁰ Thus it appears that ballet neither selects for a deep demi-plié nor trains it. These data run contrary to the belief of many ballet teachers that a deep demi-plié contributes to balletic success. It must be noted, however, that to improve reproducibility our data were collected in the “parallel” position, whereas both demi- and grand-plié take place with the hip fully turned out into ER. It would be of interest to measure plié in the functional position, although we speculate that our findings would be corroborated in this position also.

We measured ankle dorsiflexion in the parallel position as this has been shown to be reliable.^{10 15} To extend our laboratory findings to the studio setting, we assume that ankle dorsiflexion in parallel is correlated with the depth of demi-plié. Although this seems reasonable, it would nevertheless be valuable for researchers to formally correlate ankle dorsiflexion in parallel and the depth of demi-plié in the functional turned out position. If, in the unlikely event that these measures were not associated, it would provide an alternative explanation for our finding of a similar range of ankle dorsiflexion in both novice and elite dancers—that is, that the parallel dorsiflexion movement is not selected for and not trained in classical ballet.

We measured ankle dorsiflexion with the heel on the floor (to approximate demi-plié) rather than lifted off the floor (which would better approximate grand-plié) as demi-plié is the balletic movement most dependent on ankle dorsiflexion and it is vital for giving the dancer “balon” (which can be considered to be “lift”) to jumps—for example, allegro. Furthermore, adequate demi-plié is considered to be important in injury prevention when landing from jumps and also in gaining correct alignment and muscle control in slower movements in ballet—for example, tendu.

HIP MUSCLE STRENGTH

There are few reports in the literature on the hip muscle strength characteristics of ballet dancers.^{3 9} Our results show that young novice female ballet dancers had weaker hip flexors, adductors, and internal and external rotators than age matched controls even after adjusting for differences in weight. It has been reported that body weight influences the size of dynamometric measurements, with heavier individuals generally producing higher force measurements than their lighter counterparts.¹⁸ It may be that the statistical body weight adjustment was unable to account adequately for muscle size differences between the groups. There was no difference in the strength of hip abductors between dancers and controls. This indicates that the hip abductor strength of the dancers may have increased to the level of the heavier non-dancing controls through ballet training. This may be a result of the high demand for postural control in the many single leg stance positions of classical ballet that would specifically strengthen the hip abductors. Therefore a follow up study of these dancers may help to elucidate the influence of additional years of balletic training on hip strength.

CLINICAL IMPLICATIONS

This study has several significant clinical implications. Firstly, it clearly illustrates that not all novice dancers have the hip range of motion required to attain the technically correct ballet position of full turnout. Secondly, it shows that novice dancers can achieve greater non-hip ER, a non-physiological movement, which may make them prone to lower limb injury. Although this study does not prove that these findings are causally related, it provides the first evidence to support the association that dance clinicians have long suspected—that dancers with inadequate hip ER can achieve a greater turnout position through excessive non-hip ER. This is likely to be achieved by “screwing” the knee except in the rare case of dancers with exaggerated external tibial torsion. Taken together, these findings suggest that screening for hip ER, and perhaps encouraging dance teachers to permit those girls with restricted range to adopt lesser degrees of turnout (less emphasis on “flat” turnout) may reduce the tendency for young dancers to screw the knee. Such screening would serve to tailor individual recommendations for turnout but certainly should not be used as an exclusion from dancing.

We found that ankle dorsiflexion of young novice dancers is already very similar to that of their elite junior and professional counterparts. This suggests that demi-plié does not develop with training, a contention supported by the lack of correlation between dance history and dorsiflexion range of motion in this study. Hence dance teachers may not need to emphasise excessive training of deep demi-plié. Anterior impingement is a significant injury in dancers^{2 17}, and it may be due to forcing of deep plié. Thus the third clinical implication of this study, taken together with results of previous studies, is that ankle dorsiflexion requires

minimal emphasis and training as it appears to be rather fixed from a young age. This is plausible given that it is likely to be limited, at least in part, by the shape of the talar neck.

Finally, our study suggests that dancers should be encouraged to maintain range of motion in the “non-balletic” movements—for example, hip IR—as this facility appears to be considerably restricted even at a very young age. This is important as restricted hip IR is thought to contribute to injury.⁸ Strength maintenance is also important in order to maximise range of motion and maintain muscle balance between agonists and antagonists.

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Take home message

Many novice dancers do not have the hip external rotation required to attain the balletic position of full turnout, thus it would be prudent if dance teachers permitted such individuals to adopt lesser degrees of turnout.

Commentary

Following two recent large scale studies looking into dance injuries,^{1,2} further documented research in this field is welcome.

This study concentrates on novice female ballet dancers with a mean age of 9.6 years and investigates whether hip external rotation is genetically fixed. Although the movement chosen is active (compared with orthopaedic screening programmes which generally also measure passive movement³), non-hip external rotation is also assessed. This comparison is useful in giving evidence of those students who try to compensate for lack of pure hip mobility with subsequent risk of injury, particularly to the knee joint.

In this ambitious study (hip muscle strength and passive ankle dorsiflexion is also measured), there is a tendency to focus on the periphery as opposed to issues concerning core stability and its related significance.² However, it opens further discussion on safe teaching practice and possible unfounded expectations of dance students today.

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- 1 Brinson P, Dick S. *Fit to dance*. London: Calouste Gulbenkein, 1996.
- 2 Geeves T. *Safe Dance II*. Melbourne: Australian Dance Council, 1997.
- 3 Liederbach M. Screening for functional capacity in dancers. *Journal of Dance Medicine and Science* 1997;1:93–104.