The Functional Implication of Turnout
in Hip Range of Motion in Ballet Movement

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초록

턴아웃이 발레 동작의 고관절 움직임 범위에서 가지는 기능적 역할에 관한 연구

김 민 지

고관절의 외측 회전 (턴아웃)은 발레 동작을 수행하는데 있어 필수적인 요소로, 발레 무용수들은 두 발이 180도 이상의 회전을 이루는 완벽한 턴아웃을 이루기 위해 끊임없이 노력한다. 무용과학 분야에서도 턴아웃의 중요성을 인식하여 그와 관련한 다양한 연구가 이루어지고 있다. 하지만 이러한 관심과 많은 연구에도 불구하고 턴아웃이 발레 움직임 범위에 미치는 영향에 대한 연구는 미비한 실정이다. 일반적으로 턴아웃으로 인하여 고관절의 움직임 범위가 확장한다고 알려져 있지만 이는 과학적으로 아직 증명된 바가 없다. 따라서 본 연구는 턴아웃과 고관절의 동작 움직임 범위와의 관계를 분석하고, 발레 동작에서의 턴아웃이 가지는 기능적 역할을 확립하는 데 목적으로 두었다. 턴아웃과 고관절 움직임 범위는 25명의 학생 무용수를 대상으로 기능적 환경에서 조사되었다. 턴아웃의 각도는 회전식 평원반을 이용하여 측정되었고 고관절의 능동적 굴곡, 외전, 신전 움직임의 최대값은 페달로페드레(développé) 동작의 2차원 운동학적 비디오 분석으로 조사되었다. 변수간의 통계적 분석은 기술통계 (Descriptive analysis)와 피어슨 상관관계 분석 (Pearson correlation coefficients)을 실시하였다. 통계적 유의 수준은 p<0.05에서 검증되었다. 그 결과, 턴아웃의 각도가 더 클수록 고관절의 능동적 신전 움직임 범위가 더 큰 것으로 나타났으나, 고관절의 능동적 굴곡, 외전 움직임 범위와는 상관이 없었다. 이러한 결과는 턴아웃이 발레의 모든 고관절 움직임 범위에서 기능적이고 긍정적인 역할을 수행하지 않는다는 것을 의미하며, 더 큰 각도의 턴아웃이 가능한 무용수가 고관절의 외전 움직임 동작에 있어서 더 유리하다는 기존의 견해에 대해 의문을 제기한다. 연구결과를 종합해 볼 때, 발레 무용수와 지도자들은 기능적 측면에 있어 더 큰 각도의 턴아웃을 이루어 투명 하며 부상을 초래할 만한 과도한 노력을 기울일 필요가 없다는 것을 인식해야 할 것이다.

주제어: 발레(ballet), 턴아웃(turnout), 고관절 움직임범위(hip range of motion)

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I. Introduction

1. Introduction with Literature review

The external rotation of the hips, which is referred to as turnout, is emphasised in various forms of theatrical dance, especially in classical ballet (Reid, Burnham, Saboe, & Kushner, 1987). Excellent turnout has been considered as one of the basic and essential traits for successful ballet dancers (Shook, 1977) because it is required for the five basic foot positions and all classical ballet movements begin and finish with one of these five basic positions. Ideal turnout is classically defined as external rotation of both lower extremities so that the longitudinal axis of the feet is rotated 180° away from one another (Hamilton et al., 2006; Torres-Zavala, 1998). Unfortunately, only few dancers are endowed by nature with the ability to achieve ideal turnout (Clippinger, 2005).

Ideally, the external rotation of the lower extremities should primarily occur at the hip (Plastino, 2005) and additional range is from other lower extremity joints such as the knee, the ankle, and the foot (Coplan, 2002). When dancers are unable to obtain enough rotation from the hip joint, they constrain the other lower extremity joints beyond their limits to complete the turnout by usually using friction from the dance floor (Deighan, 2005; Tabor, 1999). This is likely to encourage biomechanically and aesthetically unfavourable compensations such as lumbar hyperextension, anterior pelvic tilt, excessive external tibial rotation, and excessive subtalar joint pronation (Grossman, 2000), producing excessive stress on the medial aspect of the knee, shin, ankle, and foot (Micheli, Gillespie, & Walaszek, 1984; Hamilton, Hamilton, Marshall, & Molnar, 1992). Consequently, it inevitably damages these joints and has profound effect on the potential for various acute and chronic injuries, particularly at the tibiofemoral and patellofemoral joints (Negus, Hopper, & Briffa, 2005). It is not surprising that 20% of aggravated knee pain was attributed to turnout among ballet dancers (Clippinger-Robertson, Hutton, Miller, & Nichols, 1986).

In dance literature, turnout has attracted a good deal of attention in various fields,

In these considerable research on turnout, the purpose of turnout in ballet movement has been described either aesthetically or functionally. The aesthetical purpose of turnout is supported by Coplan (2002)’s comment that dancers increase degree of turnout to appeal aesthetically. Yon (2002) also reported that turnout is the foundation for elegant and beautiful body line. The functional purpose of turnout has been also recognised by many investigators: to improve balance and allow for rapid movements in every direction (Taber, 1999); to contribute to pelvic stabilisation (Daniels, 2007); to promote flexibility and strength of the pelvis and prevent injury (Yon, 2002); to enable mechanical range of motion (ROM) to increase (Martin, Marquez, Ordonio, & Allen, 1998; Shin, 2001). Of the two purposes of turnout, this study concentrates upon the functional implication of turnout, especially the advantage in ROM.

The principle of turnout is grounded in the anatomical structure of the hip joints. Without turnout, the movements of the legs are greatly limited by the joint between the pelvis and the hip. As the leg is extended, the hip-neck meets the brim of the acetabulum so that further movement is impossible (Vaganova, 1969; Calais–Germain, 1993). Turnout allows the greater trochanter to recede and the brim of the acetabulum meets the side flat surface of the hip-neck, therefore, more freedom of movement in the hip joint is provided (Quirk, 1989). Kushner and colleagues (1990) confirmed through the use of radiography that extreme hip abduction must occur with progressive external rotation to avoid contact of the greater trochanter against the ilium.
2. Aims of the study

Although several classical ballet textbooks state that turnout enables dancers to achieve a wider range of hip movement, this claim has not yet been proven scientifically. In addition, despite abundant studies on turnout, there is scarce research that reveals the advantages of turnout in dance movement. As far as can be ascertained, only one study investigated the effect of turnout on hip abduction and found that the greater the position of turnout, the more hip abduction is achieved (Kushner et al., 1990). It was concluded that the emphasis on a good turnout has scientific merit and functional implication. However, this finding gives only a limited application because of evaluation only based on passive hip ROM. In fact, although measurement of passive ROM provides valuable information for the clinician and health care provider, measurement of functional ROM is more relevant in dance because of its predominant use while performing. Gilbert and associates (1998) maintained that the assessment of functional hip ROM seems more informative for evaluating the functional aspect of the hip ROM and more helpful in preventing injuries that are related to improper turnout. Nevertheless, the current research trend has focused its attention on passive ROM and no study has examined the implication of turnout on frequently performed hip movements - flexion, abduction, and extension - with functional ROM analysis. For these reasons, the present study questions the functional implication of turnout in hip ROM in ballet movement.

This study shall quantify the degree of active turnout and functional hip ROM, and establish a scientific conclusion referring to the role of turnout in dancers’ functional hip ROM. Based on a hypothesis that turnout is positively correlated with hip ROM, maximal turnout angle, as well as hip ROM in flexion, abduction, and extension was measured on ballet major students.
II. Methods

1. Participants

Twenty five female ballet major students (mean age 19.4 ± 1.4 years, Table 1) participated in the study. The samples were chosen from over 18 year-olds, in order to minimise factors variable related to growth. Ballet major students were selected over professionals, because of their standardised flexibility due to homogeneous characteristics, and excluded novice ballet dancers as they are likely to have insufficient muscle strength in hip region. Only females were examined, due to anatomical gender difference in pelvic appearance that affects hip ROM (Alter, 2004), although the same study needs to be tested to the male.

The participants were recruited at high school and University in Seoul, Korea. Exclusion criteria were any current or previous lower extremity and hip injuries that are likely to obstruct the degree of turnout and hip ROM. The initial eligibility of all potential participants according to the selection criteria was assessed prior to the participation in the study.

Table 1. Participant Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>19.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>165.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>49.7</td>
<td>3.0</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>18.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Initial age of ballet training (years)</td>
<td>9.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Years in ballet</td>
<td>10.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Hours/week practice</td>
<td>12.8</td>
<td>5.7</td>
</tr>
</tbody>
</table>
2. Procedures

The participants were examined right after their daily ballet class, to ensure maximum consistency of samples condition. All testing for each participant was completed in one session, with all measurements taken by the same single investigator. The testing session was carried out in the order of an interview, verbal instructions, and measurements. The interview was conducted to gain general information about the participants. Prior to testing, participants were informed of the purpose of the study, their rights as participants, and the testing procedures. All participants completed an informed consent form and medical questionnaire. The Trinity Laban research ethics committee approved this study.

3. Measurement protocols

The anatomical landmarks were found by palpation and green-coloured 25mm diameter markers were placed on the dancer’s body: right and left anterior superior iliac spines (ASIS), bilateral greater trochanter, the lateral and medial epicondyles of the femur, the lateral and medial malleoli, the second toenails, and the most distal portion of the calcaneus.

1) Active turnout

Turnout angle was measured in the first position with a pair of rotational disks, Functional Footprints (Figure 1). Typically, goniometric measurement has been employed to obtain the degree of turnout in previous studies (Gilbert et al., 1998; Martin et al., 1998; Miller, Gooch, & Haben, 1993); however, unconscious use of friction from the floor often impeded the precise examination of turnout ROM. In this regard, Functional Footprints is an appropriate apparatus with most of the friction eliminated by ball bearings (Grossman, 2003). It has rays from 0° to 90° marked in 10° intervals.
The participants were asked to stand comfortably on the rotational disks, on barefoot, and the feet were positioned to the vertical axis from the middle of the second toe to the centre of the calcaneus. Then, the participants demonstrated their maximal turnout from the hip with the arm position of en bas. This measurement was repeated three times, each reading completely independent of the previous. The qualitative criteria for acceptable trials of turnout were explained to each participant: each knee was positioned over the midline of the foot; even weight distribution over the calcaneus, first metatarsal head, and the fifth metatarsal head; even weight distribution over both feet; and external rotation of both lower extremities with extended knees. No attempt was made by the investigator to correct the dancer’s alignment.

2) Functional hip ROM

Measurements of the participant’s functional hip ROM were taken using a modified protocol from the procedure described by Martin and colleagues (1998). Since the développé is widely used in classical ballet and one example of a technique in which the ability to attain a large functional ROM is deemed to be important to the quality of a performance (Crichton, 1992), the three functional hip movements were represented as développé movement: hip flexion as développé en avant; hip abduction as développé à la seconde; and hip extension as développé derrière (Figure 2-4).
The participants were asked to perform three trials of each développé movement at the barre. Due to the relative complexity of développé movement, two-dimensional (2-D) kinematic video analysis was conducted. One tripod-mounted camcorder (SAMSUNG VP-X210L) was placed perpendicular to the sagittal plane of the développé en avant and derrière, and the other (SAMSUNG HMX20) to the frontal plane of the développé à la seconde, with the joint markers clearly visible. The height of camcorders was adjusted, so the centre of the lens was one metre above the floor, which was approximately at the hip level of the participants. A 25mm diameter yellow marker was taped to the dance floor, as a landmark for fixed distance of dancers from camcorders.

Each participant was randomly assigned for each direction of the développé. Verbal instructions consisted of “ready, and go” upon which, the participant would assume a passé position from fifth position, and then the end position of the développé front, side, and back. The arm position was à la seconde consistently. The participants performed développé movement for both legs and the movement was executed at the most comfortable speed for each participant.

Motion data was analysed using the Dartfish movement analysis programme. Functional ROM of hip flexion, abduction, and extension was determined according to the parameters listed in Table 2. The best value of three trials was obtained for analysis. Criteria for selection included smooth movement of the leg, maintenance of balance, proper alignment of the body, and proper speed of movement.
Table 2. Anatomical Landmarks

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Movement</th>
<th>Fulcrum</th>
<th>Moving landmark</th>
<th>Stationary landmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip Flexion</td>
<td>Développé en avant</td>
<td>Greater trochanter</td>
<td>Lateral epicondyle of the femur</td>
<td>Aligned with vertical line</td>
</tr>
<tr>
<td>Hip Abduction</td>
<td>Développé à la seconde</td>
<td>ASIS</td>
<td>Medial epicondyle of the femur</td>
<td>Aligned with vertical line</td>
</tr>
<tr>
<td>Hip Extension</td>
<td>Développé derrière</td>
<td>Greater trochanter</td>
<td>Lateral epicondyle of the femur</td>
<td>Aligned with vertical line</td>
</tr>
</tbody>
</table>

4. Data analysis

Only the functional turnout and hip ROM data from the dominant leg were used for statistical analysis. Pearson correlation coefficients (SPSS Version 16.0 for Windows) were calculated to examine the relationship between turnout and hip ROM. Statistical significance was established at the 0.05 level ($p \leq 0.05$).

III. Results

The average active turnout angle was 67.0° for the participants (Table 3). Active turnout ROM had no significant relationship with dance history of the participants such as the initial age for ballet, years of ballet experience, and practicing hours, respectively.

Functional hip ROM in développé movements is shown in Table 3. Measurement for hip flexion, développé en avant, ranged from 99° to 137.9°, averaging 119.8°; hip abduction, développé à la seconde, ranged from 115.7° to 153.1°, averaging 139.2°; and hip extension, développé derrière, ranged from 89.2° to 137.1°, averaging 113.7°.
Table 3. Mean of active turnout and functional hip range of motion (˚)

<table>
<thead>
<tr>
<th>Movement</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnout</td>
<td>67.0</td>
<td>8.4</td>
<td>50.0 - 90.0</td>
</tr>
<tr>
<td>Hip flexion</td>
<td>119.8</td>
<td>8.7</td>
<td>99.0 - 137.9</td>
</tr>
<tr>
<td>Hip abduction</td>
<td>139.2</td>
<td>9.1</td>
<td>115.7 - 153.1</td>
</tr>
<tr>
<td>Hip extension</td>
<td>113.7</td>
<td>12.2</td>
<td>89.2 - 137.1</td>
</tr>
</tbody>
</table>

Table 4. Correlations between turnout and hip ROM

<table>
<thead>
<tr>
<th></th>
<th>Flexion</th>
<th>Abduction</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnout</td>
<td>0.22</td>
<td>0.16</td>
<td>0.53**</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).

Pearson correlation coefficients were used to determine association between active turnout and functional hip ROM. The results of this study show that turnout ROM is indeed positively correlated with hip extension ROM, but not with hip flexion and abduction ROM (Table 4). More ROM in turnout means a possibility of achieving a greater functional ROM in the hip extension movement.

IV. Discussion

1. Discussion

It was hypothesised in this study that functional implication of greater turnout would be relevant to hip ROM in flexion, abduction, and extension movements. The present study verifies a positive correlation between active external rotation and the functional ability to achieve a greater range of extension as proposed. However, this is not enough to satisfy the popular view that turnout is critical to achieve extreme hip ROM in ballet movement. If the turnout improves only hip extension, the struggle to gain a greater turnout is unnecessary and a moderate degree of turnout would be sufficient in terms of functional purpose.
1) Turnout and Hip flexion

No significant relationship between greater turnout and flexion ROM is established in this study. This may be due to the anatomical considerations of the hip joint since the actions of hip muscles and ligaments appear contradicted in turnout and hip flexion movement. In particular, the strength of the iliofemoral ligament enhances ROM for flexion but restricts external hip rotation (Hamill & Knutzen, 2003). Also, the primary muscles for flexion movement are located at the anterior aspect of the hip, whereas, the external hip rotators are the posterior hip muscles (Clippinger, 2007). This finding thus supports the anatomical basis for hip movement.

2) Turnout and Hip abduction

The conventional belief that greater hip external rotation facilitates the hip abduction ROM is not confirmed in the study. This contradictory finding advocates the author's perspective that measurement of passive ROM is not sufficient in terms of functional application to dance performance. Since measurement of passive ROM depends on the skeletal structure, the joint capsule, tendons, and ligament, but not on muscle strength and coordination (Norkin & White, 2003), the mechanism and anatomy of bone movement determine the range of hip movement. In this context, turnout obviously benefits hip abduction movement. However, in functional ROM assessment, muscle flexibility and strength is another important factor, distinguishing functional ROM from passive one (Clippinger-Robertson, 1988). While passive ROM indicates the potential ROM of dancers, functional ROM denotes the actual extent of movement which dancers can demonstrate at the moment. Gilbert and colleagues (1998) support this with the conclusion that passive hip external rotation may not be useful in predicting functional turnout. In consideration of this, the hip abduction movement may not have scientific merit of turnout in functional context where both the joint and muscle function together.

Another possible explanation for this finding is the discrepancy in turnout ROM between static and dynamic movements (Grossman, 2000). The dancers may not be able to control turnout in all movement situations, constantly, so presented differing turnout
ROM with regard to the external hip rotation achieved for turnout assessment in first position and while executing développé movements. In first position, where both the lower limbs are in contact with the floor, both sides of the hip joint are involved in the weight bearing chain, so the hip is maintained relatively stable (Negus et al., 2005). In contrast, while performing a développé movement, the gesture leg in the développé movement is free from weight bearing, thus, the amount of turnout achieved is primarily determined by muscle strength against gravity. Accordingly, turnout ROM is likely to be different in turnout assessment and développé à la seconde. This was often confirmed by observation in this study. As an example, one dancer demonstrated almost perfect turnout angle on rotational disks, but not presented the same amount of turnout during a développé à la seconde movement. This finding challenges the conclusion of the previous studies that functional turnout for first position is considered an appropriate indicator of turnout for more complex movements (Gilbert et al., 1998; Watkins, Woodhull-McNeal, Clarkson, & Ebbeling, 1989).

3) Turnout and Hip extension

A positive correlation between active turnout and the functional hip extension is verified in this study. This may be the expected conclusion from the rationale of the ligament activation and muscle functions in hip movements. Particularly, the iliofemoral ligament and the gluteus maximus are involved in hip extension and external rotation (Gray, 1985), so the improvement in the flexibility of the iliofemoral ligament and the proper function of gluteus maximus enable both movements ROM to increase together. This result corresponds to the anatomical considerations of hip movement.

The comparison of the results of this study and previous literature is not possible, due to variation in the methods of measurement including testing positions, instruments, and procedures. In fact, there is no comparable research that employed the same methodology as this study. Because of non-standardised methods, it is obvious that there are limited and conflicting findings in this area. Therefore, the results of this study would be better to be understood as a supplementary criterion to conclude the role of turnout in ballet movement.
2. Practical application

Understanding the contribution of turnout in performing hip movement is vital. Information generated from this study assists ballet dancers and instructors. Addressing that turnout is not decisive of achieving extreme hip ROM provides two significant directions. First, dance instructors should keep a critical eye on generally accepted ideas of turnout so that the better and thorough understanding of facets of turnout would be obtained. Second, turnout from the hip and the desired lower extremity alignment should be more emphasised in class instead of excessive stress on a greater turnout. While the excellent turnout is prerequisite for ballet dancers, allowing less perfect turnout helps dancers achieve the desired alignment and prevent injuries. Developing physical mastery of turnout first in simple movements such as pliés, relevés, and tendus before progressing to its use in complex movement would be the following stage.

V. Conclusion

1. Conclusion

In this study, only hip extension movement appears to benefit from large turnout in functional context. This finding disagrees with the conventional belief that dancers with a greater turnout have an advantage in hip abduction ROM. Ballet dancers and instructors should be aware that, from a functional point of view, there is no need for excessive effort to achieve larger turnout.

2. Future suggestions

(1) This study focused its attention on the implication of turnout in hip ROM. Extended research area to other ballet movement would be a logical next step to further extend this study and establish a thorough role of turnout in ballet.
(2) The 2-D kinematic video analysis system, used in this study, had the difficulty in analysis of functional hip movement ROM, due to inconsistent hip ROM on screen. Further research with higher tech equipment, such as 3-D data capture system, is recommended for even more accurate analysis of functional hip ROM.

References

Clippinger-Robertson, K. S., Hutton, R. S., Miller, D. L., & Nichols, R. (1986), Mechanical and anatomical factors relating to the incidence and etiology of patellofemoral pain in dancers. In C. G. Shell (Ed.), The dancer as athlete (pp.53-72), Champaign, IL: Human Kinetics.


