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Determination of Ten-Repetition-Maximum for Gluteus Medius Muscle

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Abstract. A method for determining a ten-repetition-maximum (10 RM) for the gluteus medius muscle (GM) was developed with the participation of 14 healthy college students. First, a one-repetition-maximum (1 RM) was obtained with the participants in a sidelying position. Specifically, this was achieved by a tensiometer reading taken when the participant performed maximum isometric contraction of GM with the hip in 0°, 15°, and 30° of abduction. Next, determination of 10 RM was carried out by having the participant perform an isotonic GM contraction with two thirds of the 1 RM. The load was either decreased or increased depending on whether or not the participant was capable of carrying out this manoeuvre 10 times. The results showed that correlation coefficients were largest for 0° of hip abduction in comparison to those for 15° and 30° of hip abduction. For all the participants with the hip in 0° of abduction the mean proportion of the load for 10 RM to that for 1 RM was 45.9%. Also this position of 0° abduction showed the smallest dispersion of the three angles in hip abduction. It was concluded from this study that, for progressive resistance exercise for GM, 40 to 45% of 1 RM obtained in 0° of hip abduction can be used for calculation of 10 RM.
Key words: Repetition-maximum, Progressive resistance exercise, Gluteus medius muscle.

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INTRODUCTION

Restoration of muscle power to perform normal activities is often one of the important treatment aims of physiotherapists for their clients. Among the many methods of muscle strengthening that are most widely used is the application of progressive resistance exercise or PRE devised by De Lorme et al[1]. De Lorme's method is based on the principle of ten-repetition-maximum or 10 RM, which is the maximum load an individual can exert against gravity no more or no less than 10 times with his/her maximum effort. De Lorme determined 10 RM in PRE for the quadriceps femoris muscle by having the client lift a five-pound, or 2.27 kg, weight attached to the distal end of the tibia, then added to this a minimum of one and a quarter pounds, or 0.57 kg, up to a maximum of five pounds, or 2.27 kg, successively so as to obtain a sufficient load to accomplish complete extension of the knee 10 times[2, 3]. But, as physiotherapists are well aware, this can, at times, be a 'hit and miss' method.

An alternative suggested method to determine 10 RM is derived from the authors' own experience and, that is, to take approximately two thirds of the maximum isometric strength that the individual can generate with one maximum exertion, which is known as the one-repetition maximum (1 RM)[4]. However, according to Hirota and his associates[5, 6], 10 RM for the quadriceps femoris muscle is equal to

55 per cent (%) of its maximum isometric strength with the knee flexed at 60°. In this case one completes 10 times the full range of knee excursion from 90° of flexion to 0° of flexion/extension. However, from the authors' clinical experience the above method seems applicable only to the quadriceps femoris muscle; two thirds, let alone 55%, of 1 RM for 10 RM of the glutei is often beyond the capability of many clients. We strongly believe this statement to be correct because of the lever arm's length and muscle bulk; for instance, the lever arm for the glutei is approximately twice as long as that for the quadriceps when the leg is exercising with the knee in extension, and the muscle bulk of the hip musculature is smaller than that of the quadriceps femoris.

The gluteus medius muscle (GM) is one of the important anti-gravity muscles of the lower limb and a principal abductor of the hip joint. This muscle gives lateral stability to the trunk and pelvis during one-leg standing and stance phase of walking. Because of the nature of the important functions this muscle plays it becomes vulnerable when lower limb pathology and/or lesions occur, and an early recovery is imperative whenever it is weakened. Consequently, PRE is the most common method employed for regaining the strength of this muscle. There is, however, no simple clinical or scientific method for calculating 10 RM for this muscle. Therefore, the purpose of this study was to develop, as scientifically as possible, a simple and convenient method to determine 10 RM for PRE to strengthen GM. The significance of and benefits from this study would be that, with the establishment of such a method for 10 RM determination, it would provide an accurate method for the physiotherapist to calculate a suitable load for the individual client. In addition, it would avoid unnecessary fatigue, pain and anxiety on the part of the client during grading of the load for PRE performance. Also of importance is that treatment time would be saved, for cost-effectiveness is vital in today's healthcare.

PARTICIPANTS AND METHOD

Selection of the participants

We selected seven healthy male and seven female college students with ages ranging from 20 to 29 years. The participants demonstrated no past history of hip conditions or injuries.

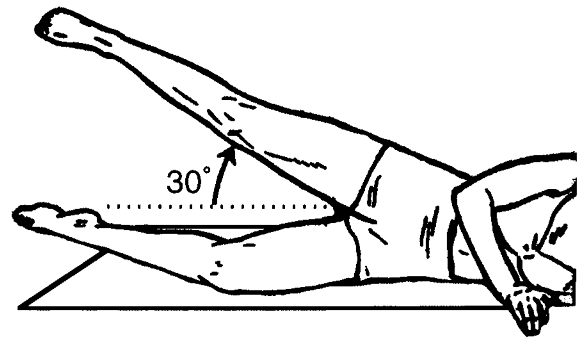

Fig. 1. Testing position for the gluteus medius muscle in 30° of hip abduction. All equipment has been deleted from this diagram.

Measurement procedure for the 1 RM

The gluteus medius of the dominant leg was tested. The dominant leg was operationally defined as the one which is normally used to kick a ball. The participant was positioned in sidelying with the dominant leg uppermost for measurement with the hip slightly extended beyond the midline, and the under-leg bent for stability of the trunk (Fig. 1)[7], with fixation of the pelvis by a pelvic belt. The under-arm supported the head, and the palm of the upper-hand was placed on the MKY exercise plinth (type DY-131, Yaesu Rehab Equipment, Inc., Japan). A 14-centimetre wide leather cuff was attached one cm above the medial malleolus, to which a wire was connected from the floor, and a tensiometer (type K48, Yagami Rehab Equipment, Inc., Japan) was placed on the wire. This tensiometer had a measurement accuracy of 0.1 kg_W with a measurement range of 0 kg_W to 100 kg_W. The point for the wire attachment to the floor was determined so that the wire and the leg were at a right angle. With the examiner's verbal command of "Keep the knee straight and pull the wire towards the ceiling as hard as possible" the participant performed one maximum isometric contraction of GM with the hip in one of the randomly decided positions of abduction; specifically, neutral or 0°, 15°, and 30°, and this was maintained for three seconds, and the tensiometer reading was recorded. Measurements for GM at the other two angles of hip abduction were carried out on different days.

Measurement procedure for the 10 RM

Measurements for the 10 RM procedure were also carried out on different days in random order for each of the three abduction angles. Specifically, the dominant leg was connected by means of a cuff to a rope at the distal end of the tibia and this was connected to a pulley, and the participant performed isotonic contractions of GM 10 times. Loading GM with two thirds of the 1 RM, each of the 10 lifts required three seconds each; the first second to complete full abduction, the next second to maintain it, and the third second to return the leg to the starting position, respectively, in synchronization with a metronome (Seikosha, Inc., Japan) set at 60 beats per minute. The number of lifts the participant could perform with his/her maximum effort was recorded. When the number of lifts were less than 10, the load was decreased by an increment of 0.25 kg, and when the number of lifts were more than 10, the load was increased by an increment of 0.25 kg. In this way 10 RM was determined when the participants performed maximum loaded hip abduction only 10 times with his/her maximum effort.

The experiment took place between 0900 and 1100 hours and 1300 and 1600 hours. The ambient room temperature was maintained at 18 to 24 degrees Celsius during the experiment. The procedures and risks of the study were explained to the participants before the experiment took place, and their written informed consent was obtained.

Data Analysis

Correlation coefficients and regression equations were calculated for the male only group, female only group, and the combined groups. Using Student's t test we examined the statistical significance of the correlation coefficients for each of the angles at 0°, 15° and 30° of hip abduction with the level of significance at 0.05. Also examined was the mean (and standard deviation or SD) proportion of the load for the 10 RM to that for the 1 RM.

RESULTS

The correlation coefficients were as follows: 0.89 for the hip in 0° of abduction for the males, 0.95 for the females, and 0.99 for the combined group, all of which were significantly high. The correlation coefficient with the hip in 15° of abduction was 0.71 for the males, 0.66 for the females, and 0.93 for the combined group. The correlation coefficient with the hip in 30° of abduction was 0.67 for the males,

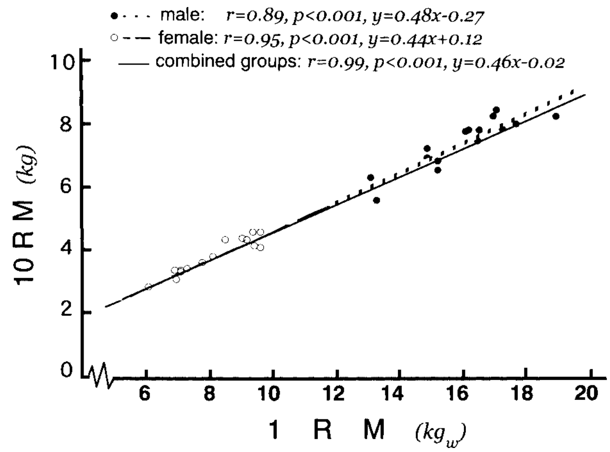

Fig. 2. Correlation between 1 RM and 10 RM in 0° of hip abduction.

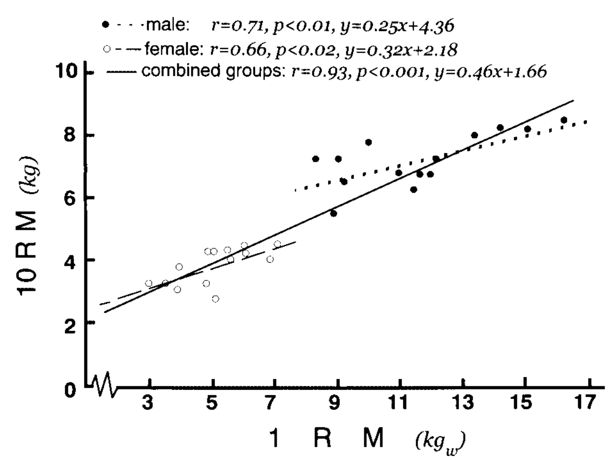

Fig. 3. Correlation between 1 RM and 10 RM in 15° of hip abduction.

0.39 for the females, and 0.91 for the combined groups; the correlation coefficients for the males and combined groups showed a statistical significance, but the female's was non-significant. Figures 2, 3, and 4 show the correlation between 10 RM and 1 RM with the hip in 0°, 15° and 30° of abduction with the provision of a regression equation for each.

The raw data for each participant's proportion percentage of the 10 RM to 1 RM is shown in the Table 1. The mean proportion of the load for the 10 RM to that for 1 RM in 0° hip abduction was 45.9% for the males, females, and combined group with an SD of 2.5% for the males, 2.1% for the females, and 2.3% for the combined group. With the hip in 15°

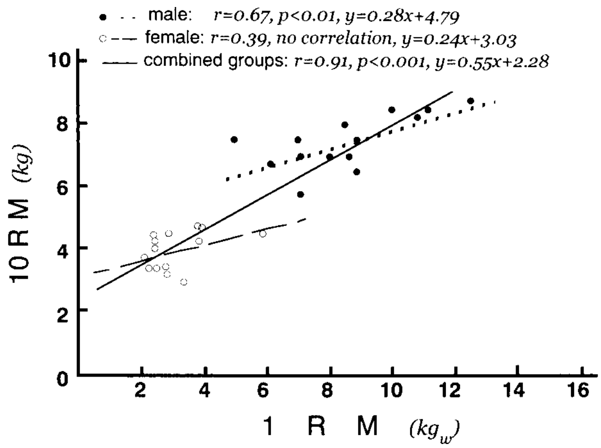

Fig. 4. Correlation between 1 RM and 10 RM in 30° of hip abduction.

of abduction the mean (SD) proportion for the males was 64.4 (10.6) %, females 75.4 (16.0) %, and combined group 71.0 (14.5) %, respectively. With the hip in 30° of abduction the mean (SD) proportion for the males was 87.8 (19.4) %, 123.9 (28.0) % for the females, and 105.8 (30.1) % for the combined group, respectively. In addition, the difference in proportion did not yield a statistical significance between the males and females with the hip in 0° and 15° of abduction.

DISCUSSION

Regarding the relationship between 1RM and 10RM in this experiment, the correlation coefficients for 0° of abduction were high compared to those for 15° and 30° of abduction in the males, females, and combined groups. The reason for this seems to reflect the difference in the range of muscle work during the 1 RM measurement, for contraction of GM at 0° of hip abduction occurs in its middle range, which is the most efficient range for generating its maximum power. However, the correlation coefficients of all the participants fell somewhere between 0.99 and 0.91, which was much higher than the findings of 0.80 to 0.85 resulting from Hirota and his associates' study for the quadriceps femoris muscle[3)]. One factor for the high correlation in our study may be that we used an increment weight or measurement accuracy of 0.25 kg, instead of one kg which Hirota and his associates used for determining 10 RM in their experiment for the quadriceps femoris muscle[5)].

These findings demonstrated that the smallest dispersion was among those participants in 0° of hip abduction, and 15° of hip abduction showed a relatively large dispersion in the females and 30° of abduction showed a large dispersion in both males and females. The implication of this is that 0° of hip abduction is the most advantageous position for determination of 1 RM for PRE to strengthen GM.

With the hip in 0° of abduction, the proportion of

Table 1. Each participant's proportion in percentage of 10 RM to 1 RM

Participants	Sex	Left GM			Right GM		
		0° abd	15° abd	30° abd	0° abd	15° abd	30° abd
1	M	49.0	59.4	81.5	48.8	55.0	82.5
2	M	49.0	79.1	91.2	50.0	52.5	68.0
3	M	44.4	62.5	77.6	41.7	64.0	77.5
4	M	44.8	80.6	145.0	42.8	70.7	104.8
5	M	44.0	88.4	103.6	45.6	57.2	95.1
6	M	43.9	58.5	73.7	45.5	60.2	74.1
7	M	45.6	58.2	84.4	48.1	55.3	70.2
8	F	44.7	77.3	141.7	46.7	69.7	73.3
9	F	41.7	71.4	160.0	45.7	96.2	150.0
10	F	46.9	75.0	112.5	47.2	88.5	170.0
11	F	43.5	75.0	103.4	46.4	108.3	130.0
12	F	47.1	92.9	116.1	45.8	53.9	78.6
13	F	47.9	63.4	115.4	42.6	58.0	100.0
14	F	50.0	83.3	141.7	45.8	67.7	141.3

Abbreviations: GM, gluteus medius; abd, hip abduction; M, male; F, female.

10 RM to 1 RM was the same for all the participants resulting in the smallest dispersion. This dispersion was also smaller than that of 6.6 to 8.8% derived from Hirota and his associates' study[5]. This difference may also be similarly explained by such factors as high measurement accuracy and high correlation in this study.

Based on these findings, it seems reasonable to take 40% to 45% of the 1 RM as a measurement tool for 10 RM in PRE for GM with the hip in 0° of abduction. However, these findings cannot be extrapolated directly to clients, because participants in this study were all healthy young men and women with no musculoskeletal pathology of their hip joints.

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