

Exploring Natural Fitness Instincts: Motion Capture, dumbbells and biceps curls

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Abstract

This paper and the experiment carried out deal with the research question:

How does the natural use of dumbbells, especially in relation to the form and technique during biceps curls, vary among individuals?

A group of 7 participants with different previous experiences and fitness levels were observed. Data on these areas was collected beforehand using a questionnaire.

During the practical phase, participants did 12 bicep curls with each arm using a 5kg dumbbell without prior technique instructions. The exercises were recorded with a Qualisys motion capture system, using 3 markers on each arm and 2 markers on the dumbbell.

The data shows that there are differences between the participants in various categories such as duration of execution, range of motion and previous weight training experience. Potential improvements are also identified.

Keywords: motion capture, biceps, exercise, range of motion, weight training

1. Introduction

This study tries to investigate the intuitive use of dumbbells in weight training. One goal is to identify potential variations in execution techniques among individuals with differing fitness backgrounds and knowledge about weight training. While other research focuses on muscle growth in certain areas (Pedrosa et al., 2023), grip (Coratella et al., 2023), tries to understand the muscles' response to different

amounts of load (Dereshgi, 2023) or detects anomalies (Kowsar et al., 2016) the primary question is to observe natural fitness instincts in weight training. Dumbbell curls are used as the exercise to be observed. Can differences be observed between the individual participants? Do these perhaps allow conclusions to be drawn regarding previous experience?

2. Experiment setup and methods

7 participants (colleagues and professors from our university course) took part in the experiment. They were asked to complete a digital questionnaire (Microsoft Forms) to collect general information and details about their fitness experience including age (between 24 and 41), gender (3 female, 4 male), current fitness level, motivation for exercising, fitness background, experience with professional training in weightlifting or strength training, how they informed themselves about training with weights and previous experience with dumbbells.

In the practical phase of the study, each participant was provided with a 5kg dumbbell. The participants were only told to perform 12 repetitions of biceps curls with each arm (Kent, 2016). No specific instructions on the exercise were given beforehand, as the technique was to be chosen by the participants themselves in order not to hinder their instinctive execution. They were only told to do 12 biceps curls with each arm and to start with the right arm. The participants were also asked to take a short break between the two sets to make the recording process easier.

The participants' movements during the exercises were recorded using a Qualisys motion capture system and its software QTM (Qualisys Track Manager). QTM recorded at a frame rate of 100 frames per second. 3 markers were placed on each arm (shoulder, elbow, wrist) and 2 markers were used on the dumbbell (Motion Capture – Mocap, 2023).

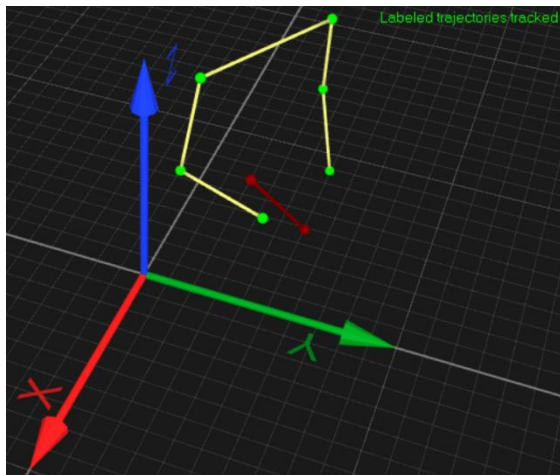


Figure 1. Screenshot QTM.

3. Results

The group of participants (3 female, 4 male) can be described as “quite active”. In the preceding questionnaire, 2 people described themselves as "sometimes active", 3 as "regular exercisers" and 2 as "very active". Nobody chose the self-descriptions "not active" or "rarely active". Only one in 7 participants had never used dumbbells in his or her fitness routine. While only 2 out of 7 had ever received professional training in weightlifting or strength training.

The participants also mentioned that they had at least 5 years of practice experience in regular fitness or exercise activities. The group's median age was 27 years. When asked about their motivation for exercising, 6 out of 7 participants cited health as an important factor. Stress relief was also mentioned by 4 of the 7 participants. 5 out of 7 participants had stated that they had already informed themselves about training with weights using books, online tutorials, etc.

„Variation (in various forms)“ can be identified as the main finding of the experiment, although a self-described "active" group with prior knowledge was studied. The graph below clearly displays variation as an important characteristic of the recorded data. Not only the execution time, but also the range of motion in degrees differs depending on the participant.

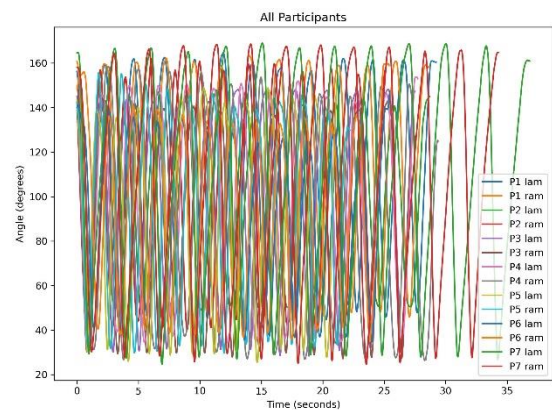


Figure 2. All participants: angle (in degrees) and duration.

If you compare the slowest and the fastest participant, for example, you can notice obvious differences in the range of motion and duration of the exercises.

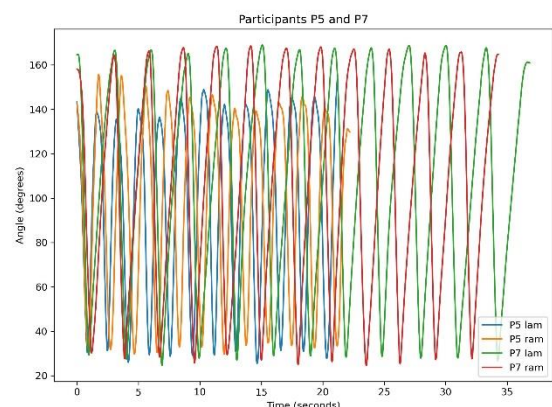


Figure 3. Participants P5 and P7.

The median of the average range of motion of the entire group was approx. 98 degrees, although it should be noted that participants who described themselves as „very active“ tended to have a greater average range of motion (approx. 105 to 111 degrees).

These two “very active” participants were also the slowest. In particular, participant P7 chose a much slower execution of the dumbbell curls.

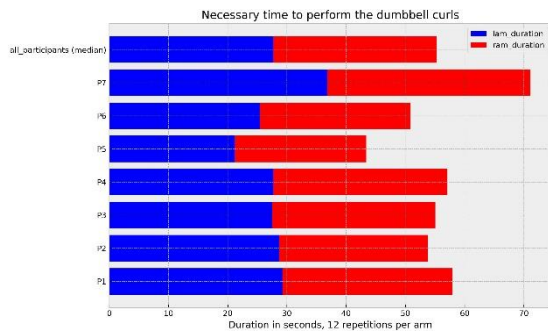


Figure 4. Execution time of 12 biceps curls.

The analyzed data shows that there was not only a different range of motion when performing the exercises within the group, but also that each person showed varying degrees of flexion between the left arm and the right arm.

Table 1. Average range of motion during the experiment.

Average range of motion during the experiment		
Participant	left arm	right arm
P1	110,21°	111,06°
P2	98,10°	100,30°
P3	99,09°	93,58°
P4	92,85°	88,99°
P5	95,74°	97,35°
P6	91,25°	95,51°
P7	107,70°	105,30°
Average	99,28°	98,87°
Median	98,10°	97,35°

The average range of motion was from 91,25° to 110,21° on the left arm and from 88,98° to 111,06° on the right arm. The average range of motion of the entire group can therefore be determined as 99,28° for the left arm and 98,87° for the right arm. The median was 97,35° on the right arm and 98,10° degrees on the left.

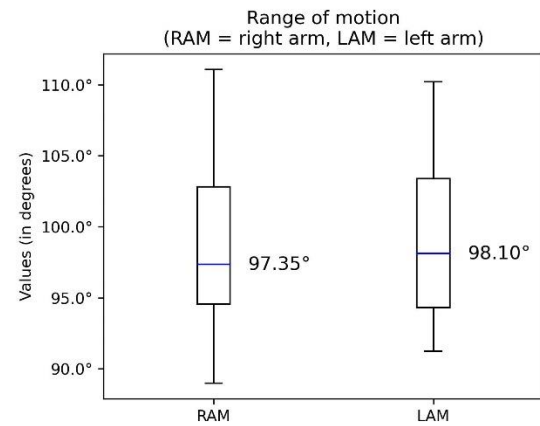


Figure 5. Average range of motion of all participants.

4. Conclusions

This study sought to investigate natural fitness instincts and to visualize possible differences in the execution of dumbbell curls. It was possible to record the differences in the execution of a weight training exercise using a motion capture system. These differences were made measurable in the areas of range of motion and duration. Although this objective was achieved, several points have emerged that should be taken into account in a possible follow-up experiment.

One unit of measurement that should have been included in the analysis was the distance traveled by the elbow of the performing arm. This value has been recorded, but it still seems unclear how it actually affects dumbbell curls. It still needs to be determined to what extent the elbow movement could be an important influencing factor and how more effective measurement could be done using QTM. One problem that only became apparent after the recording session was the fact that not enough attention was paid to anatomically correct, standardized positioning when attaching the markers.

In addition, it must be mentioned that with 7 participants only a relatively small number of data is involved, and a larger number could have made the results more meaningful.

Furthermore, the recording session should have been organized differently. During the recording process, only one participant should have been present in the recording room (MediaLab der Philologisch-Kulturwissenschaftlichen Fakultät, Universität Wien) at any given time. More variations of dumbbell curls could probably have been recorded, as this would have prevented the participants from being influenced by each other. In the experiment carried out, the participants were able to observe their predecessors and adopt the type of dumbbell curls. One participant had never done dumbbell curls before, so it would have made sense to include these uninfluenced exercises. With this approach, it would have been possible to learn more about the fitness instincts of the observed group.

The results of this experiment raise numerous questions. Further research should aim to define the „perfect“ technique/form to be able to analyze the „correctness“ of fitness exercises. (Figure 1 in Oliveira et al. (2009) is an example that could be used for orientation.) Parameters like skewness of movements, ideal starting points and a measurement scale for "wrongness" of execution should be considered.

The following research questions could be interesting for researchers:

- Do more experienced participants train the initial range of motion more (to have “better” results)? (This research question refers to the article of Pedrosa et al. (2023).)
- Do participants who have less experience with weight training prefer the final range of motion because it is less exhausting?

5. References

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