# Analysis of Postural Imbalance Due to Handling Weights During Physical Activities

D. Cotoros, C. Druga, I. Serban, and A. Stanciu

**Abstract**

Present paper is based upon a thorough analysis using specific devices in the Medical Engineering Laboratory meant to study the influence of handling various weights on the postural balance and implicitly on the health conditions. The weight was handled in different positions of the weight and it was lifted either by bending the body and keeping the legs straight or by bending the knees. The imbalance was determined by analyzing the aspect of the stability area using a Kistler force platform.

**Keywords**

Weight handling • Stability area • Imbalance • Force platform

## 1 Introduction

Handling weights can be a basic daily activity or an important part of training for improving sportive performance or rehabilitating weakened muscles. According to some prestigious sports associations, physical activities requiring weight lifting can be beneficial for reducing cardiovascular diseases risk by improving blood pressure and also glucose metabolism [1, 2].

Some studies found that isometric efforts of lower intensity and dynamic resistive exercises are not a negative influence upon symptoms of cardiovascular diseases, being even more beneficial than treadmill exercising [3].

Muscle weakening and poor balance can also be the main causes in accidental falls, especially for elderly people or people recovering from various locomotion impairing events [4].

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Other studies concluded that imbalance may occur due to the difference of strength between the dominant and non dominant limb as a result of previous injuries or specific sports demands [5, 6].

On the other hand, skilled and high performance weight-lifters present a limited range of motion (ROM) in the shoulders area and display less possibilities of learning new types of motor skill according to [7].

The problem to be addressed is regarding the imbalance occurred due to the inclusion of an additional weight in different positions of the body and limbs. It is a well known fact that for a human body standing, the center of mass is located at approx. 55% of the height (around the belly button), while for a bent over body it will shift outside it.

Adding weight lifting to the body posture will lead to a certain imbalance because the center of mass will shift accordingly and the human body will adjust its position in order to maintain balance.

## 2 Experimental Setup

Experimental tests were performed upon a sample of 22 persons (7 males, 15 females) aged 21–23, students in Medical Engineering and Optometry who agreed to perform the weight lifting in various positions.

All subjects are healthy and do not suffer of any neurological or physiological disease.

The equipment used for determining the degree of imbalance of the body during weight lifting is a Kistler force platform and the weight is a standard 5 kg dumbbell.

The subjects were instructed for the first stage of the experiment to maintain equilibrium in a neutral anatomic position on the force platform for 30 s in order to have a reference term for comparing the stability area after performing the weight handling. Neutral position with an intermediate base of support usually means that body weight is equally distributed upon the two feet. The measurements



S. Vlad and N. M. Roman (eds.), *6th International Conference on Advancements of Medicine and Health Care through Technology; 17–20 October 2018, Cluj-Napoca, Romania*, IFMBE Proceedings 71,
https://doi.org/10.1007/978-981-13-6207-1_5

**Fig. 1** Subject in neutral position

were made 3 times for each subject for the neutral position, as shown in Fig. 1.

For the second stage the subjects were instructed to pick up the weight in front of them keeping the legs straight, as shown in Fig. 2.

Then the subjects had to pick up the weight in front of them and bend their knees while they were doing this, as shown in Fig. 3.

Next stage required picking up the weight laterally and use whatever position they want for their knees. All subjects

**Fig. 2** Subject bending keeping straight knees, weight in front

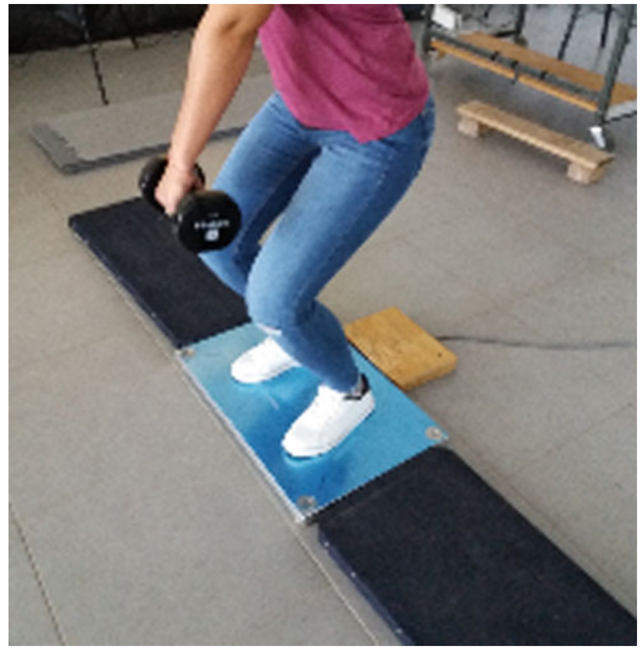

**Fig. 3** Subject bending knees, weight in front

considered the motion possible only by bending the knees, as shown in Fig. 4.

Next the subjects were instructed to bend their body, keep the legs straight and lift the weight using their right hand (dominant) first to the front of the body keeping a straight elbow, then laterally and up keeping the elbow straight again. Measurements were also made for the situation when the upwards lift was made with a bent elbow.

Finally the subjects had to bend their knees to pick up the weight and perform the same motions as in the previous stage, then set it back again.

**Fig. 4** Subject taking the weight laterally with bent knees

Measurements results acquired by help of the Kistler force platform and a connected laptop were processed using Bioware software. The information provided by each measurement concern the variation of forces on 3 perpendicular axes, variation of moments and also the stability area which shows the projections of the center of mass on the supporting surface during the entire recording.

As the problem we approached was regarding the balance, the most expressive information was provided by the stability area and the changes occurring due to weight support variation, changes that may indicate which positions are producing less imbalance upon the human body and implicitly less possibilities of producing accidents or fall over.

## 3 Results and Discussions

According to the statistics provided by the software, the range of the center of mass deviation in the stability area was between 0.025 and 0.07 m on Ox and 0.02 and 0.027 m on Oy, during maintaining the neutral position (static), some examples of the obtained diagrams are shown in Figs. 5 and 6.

Obviously not all subjects have the same sense of balance although their ages are similar and they are all in good health conditions. Interviewing the subjects it came out that some of them were performing sportive activities in their free time and as a result their balance was considerably better.

In Fig. 7, there is an example of diagram for the case when the weight was picked up with straight legs from the front of the subject.

The diagram shows clearly the occurrence of imbalance not only on the Oy direction where the weight is but also on lateral direction Ox, due to the adjustment efforts made by the body to maintain balance. The variation of the center of mass position on Oy increases to 0.045–0.055 m on Oy and to 0.07–0.095 m on Ox.

The variation of the reaction force between the feet and the ground is also interesting to watch, as the weight lifting is clearly visible on the diagram, see Fig. 8. The reaction force will increase suddenly after 5 s with roughly 40 N, with an obvious oscillation at the picking up moment (immediately after second 5).

Figure 9 is an example for the situation when the weight was picked up with bent knees from the front of the subject.

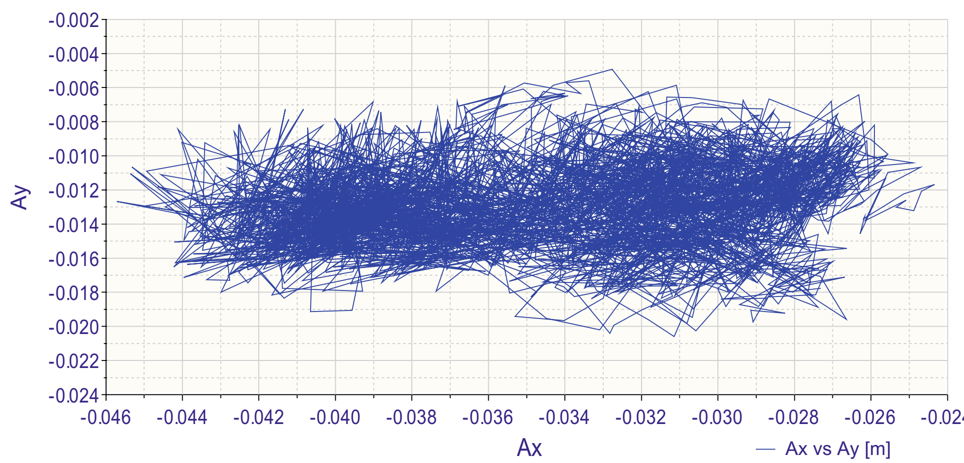


**Fig. 5** Stability area in neutral position for a well balanced subject

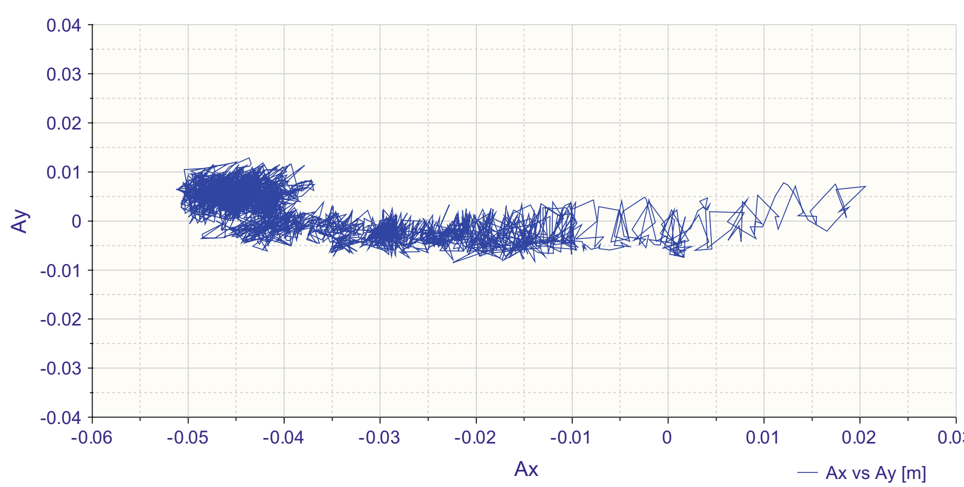


**Fig. 6** Stability area for a poor balanced subject

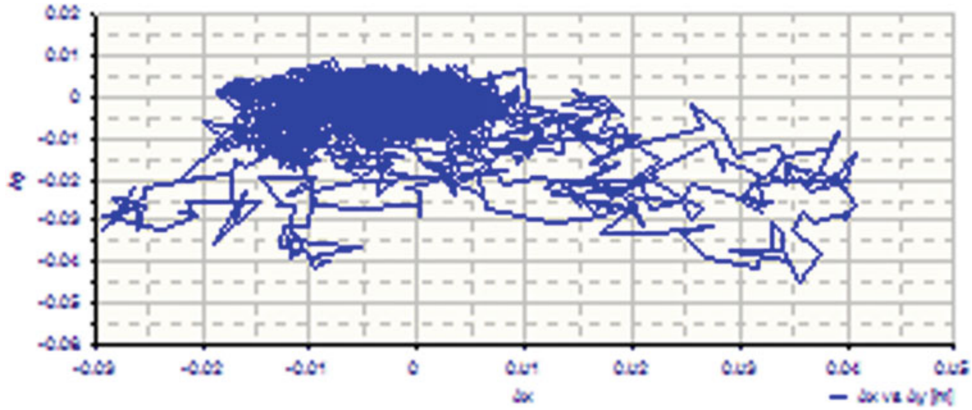


**Fig. 7** Stability area for subject picking up weight with straight knees, weight in front

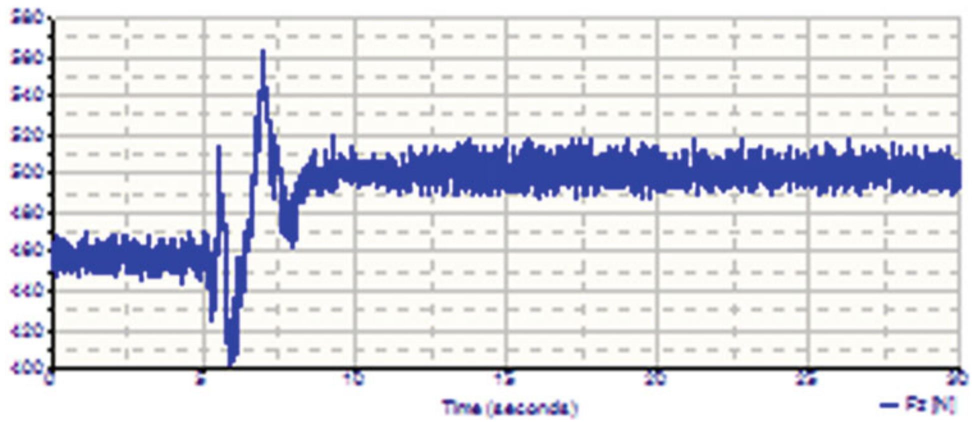


**Fig. 8** Reaction force variation during weight lifting

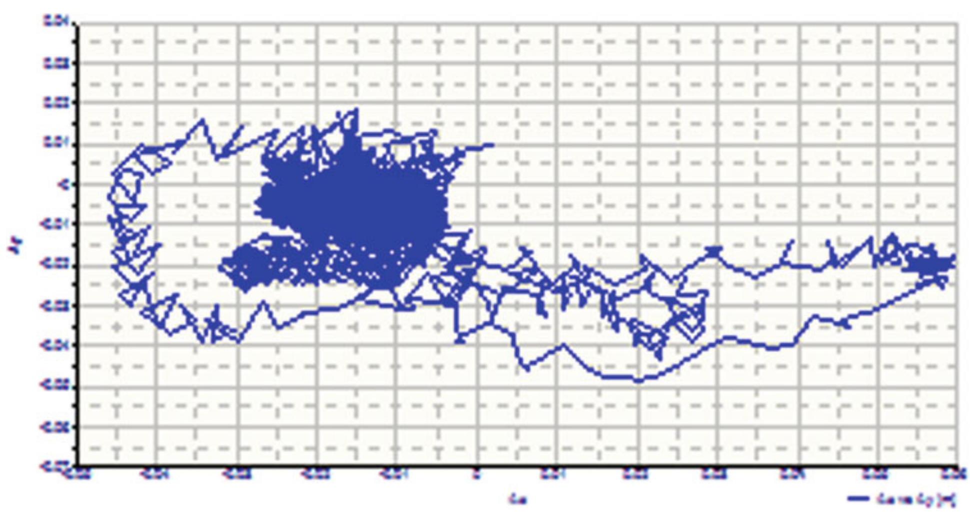

**Fig. 9** Stability area for subject picking up weight with bent knees, weight in front

The imbalance on Oy direction reaches between 0.04 m and 0.066 m, while along the axis Ox it goes somewhere between 0.08 and even 0.11 m, which is much higher than the situation with straight knees.

Figure 10 shows the variation of the reaction force for the bent knees situation. Obviously the force will increase after picking up the weight with roughly 50N and presents a strong variation while picking up the weight.

When the subjects were asked to pick up the weight which was placed laterally, they found it was possible to take it only by bending their knees. An example for the stability area in this particular situation is shown in Fig. 11.

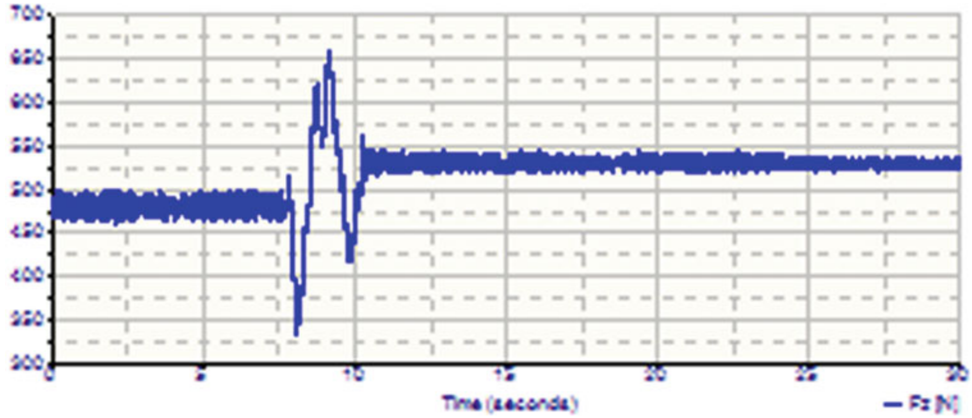


**Fig. 10** Variation of reaction force with bent knees lifting

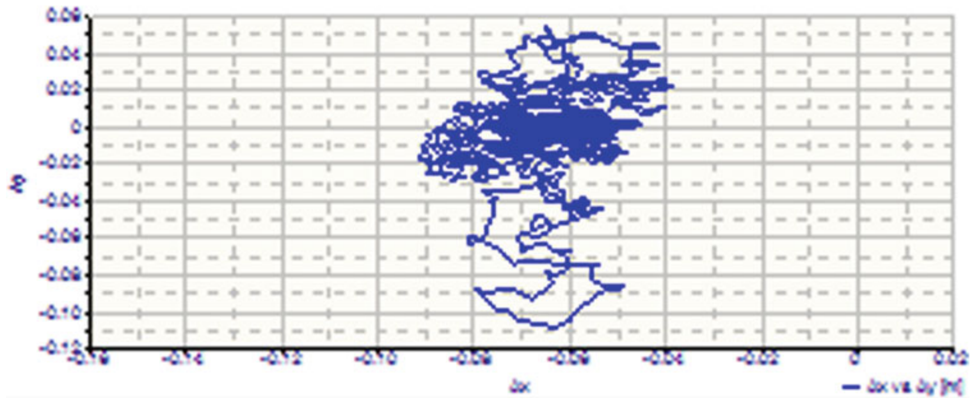


**Fig. 11** Stability area for subject picking up weight laterally

The display of the stability area shows an interesting spreading, imbalance was higher on the axis Oy (perpendicular to the direction of weight lifting) and lower on the axis Ox, demonstrating that the subject is trying to adjust by increasing the displacement along an axis perpendicular to the one where the load is acting.

The next phase of the experiment required the subjects to pick up the weight and move the arm forwards, laterally and upwards, first with a straight elbow and then upwards with the bent elbow. Some examples for the stability areas in these situations are shown in Figs. 12 and 13.

The imbalance is higher on the axis Ox (lateral direction) going up to 0.14 m and not too high on the axis Oy, reaching a maximum of 0.05 m. Both areas show striking similarities proving the fact that the position of the elbow does not influence the degree of imbalance.

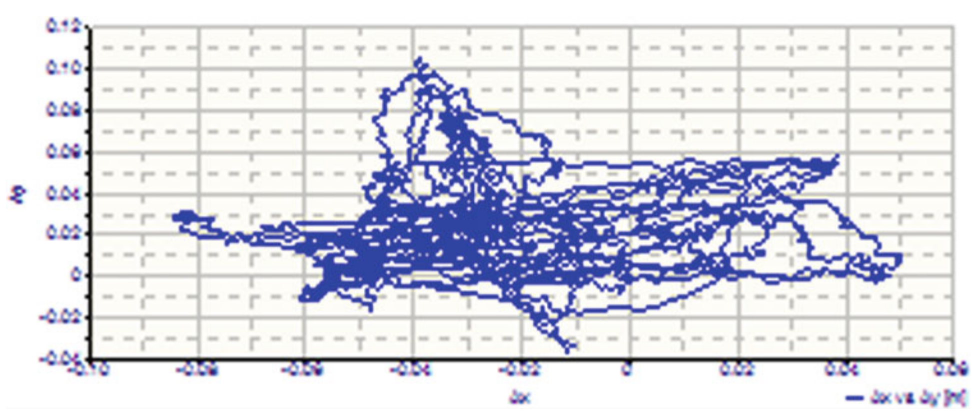


**Fig. 12** Stability area when moving the weight and keeping the arm straight

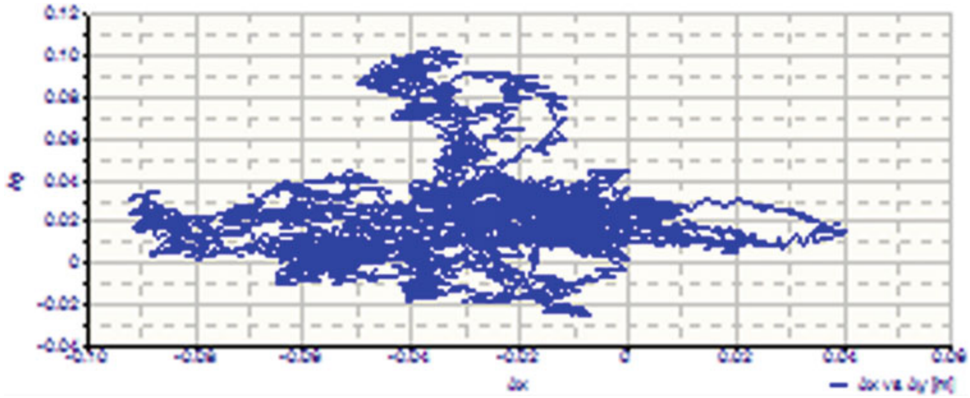

**Fig. 13** Stability area when moving weight and bending elbow

## 4 Conclusions

The necessity of lifting various weights may occur not only in sportive activities but also during daily jobs or housework. Even if the weight is moderate a certain imbalance of the body center of mass will occur, leading to additional strain on muscles for adjustment or even upon the joints. If the imbalance reaches higher values the body strain for adjustment will also be higher, besides accidental trips or falls may endanger the subject.

The experiments proved that the loss of balance is higher on a perpendicular direction to the one where the weight is placed. Also the imbalance is higher when the knees are bent during the lifting because an additional motion of the body intervenes. Also the position of the elbow during the displacement of the arm holding the weight does not influence the balance in a significant manner.

**Acknowledgements** All experiments were performed within the Advanced Mechatronic Systems Research Centre from Transilvania University of Brasov.

**Conflict of Interest** The authors declare that they have no conflict of interest.

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