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Original scientific paper

Ergonomical comparision between the back function tests

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Abstract

Background and Purpose: *In this study we showed a comparison between two methods of measuring the back function, because it is still unclear exactly what the back function tests actually measure. Back lifting and extension tests (isometric back extension endurance) are commonly used methods in judgment of work ability and rehabilitation. Some new devices (isokinetic apparatus) are now in us,e which could help in the more descriptive judgment of human back mechanical capacity.*

Material and Methods: *Previous isometric measurements that we have done earlier, were used as a control group of data, but they referred to the measuring of lumbal moments which depended on pulling forces, and inclination of the trunk, as well as the age of subjects.*

Results: *New isokinetic devices incorporate what we call today active dynamometry. In such devices servo motors and microprocessors have transformed early machines into fast and dynamic tools offering instant data analysis and reproducibility. This change in the fundamental data collection process finally sparked large scale interest in isokinetic testing.*

Conclusion: *Using this method we found that it was possible to get results on which performance is mainly influenced by heredity and behavioral factors, i.e. it assesses the physical capacity for lifting, which means that it may prove difficult to alter isokinetic lifting capacity by interventions, thus indicating that behavioral factors may play more influential roles.*

INTRODUCTION

Predictive state for return to work after low back pain *(3)* or need for rehabilitation can be evaluated through back function performance. According to literature sources, it is still unclear what exactly the back function tests actually measure. In evaluating working capacity of the determinants of back function, it seems that more accurate interpretation of the back function should be better than provided by isometric tests.

Previous isometric measurements that we had done earlier (Labar, Muftić, Jurčević, etc. 2, 1998.), are here presented as the control group of data, but they refer to the measuring of lumbal moments which depend on pulling forces and inclination of the trunk, as well as the age of subjects and their statistical distribution.

Brief presentation is also given of new isokinetic devices which are now incorporated as a measuring apparatus referred to today as active dynamometry. In such devices, servo motors and microprocessors transformed the early machines into fast and dynamic tools offering instant data analysis and reproducibility. This change in the fundamental data collection process finally sparked large scale interest in isokinetic testing.

Using this method, we found that it is possible to get results on which performance is mainly influenced by heredity and behavioral factors, i.e. it assesses the physical capacity for lifting, which means that it may prove difficult to alter isokinetic lifting capacity by interventions, thus indicating that behavioral factors may play influential roles *(3)*.

This results were impetus for very wide experiments that measured the different values of safe forces, at three different body postures (erect, half bent and bent posture) for males and females in the age range from 18 to 70 years. Figure 1 shows the general principle of measuring the pulling force that was measured by means of a dynamometer. By knowing the segmental weights and measured force on the weighing machine, we had the forces in Figure 12 made out from photographs which we did for each measuring. Safe force has been limited with the force of friction F_t.

Isometric tests

Measurements were done in »statical« conditions, each measurement g in duration of four seconds. Also. each measuring was repeated three times after one minute of relaxation of examinee *(2)*.

The mentioned experiments resulted in diagrams that represent relations between the age of subjects and their measured double hand pulling force and calculated values of lumbar moments on the spine level of L4/L5. The used model is planar one and is shown in Figure 2.

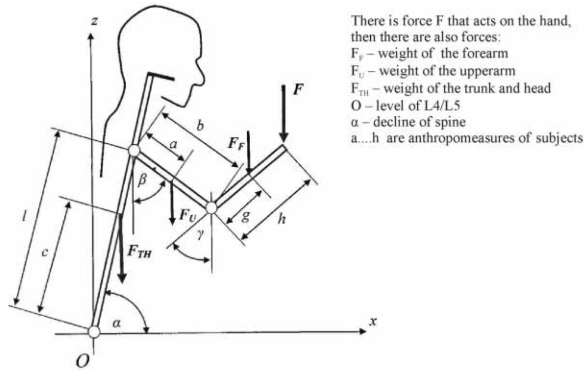

Figure 2. *Planar biomechanical model of the human.*

The differences of pulling forces between males and females are obvious, and they are in the range between 25% to 30%. Similar relations also hold true in the values of lumbar moments.

As mentioned earlier, several investigations have shown that the stress imposed on the trunk in various handling tasks induces a pressure rise in the abdominal cavity (Morris, Davis, Stubbs, Troup, Muftić 2, 1998).

This pressure acting upwards on the diaphragm, downwards on the pelvic floor, frontally on stomach muscles and on the back side of the spine and lumbar muscles. Also, this pressure relieves as portion of the stress applied to the spine. We can therefore conclude that is necessary to try to determine relations between average cross-sections of the abdomen in the function of human height.

The lumbar moment was determined by means of a biomechanical model by deriving data from the subject

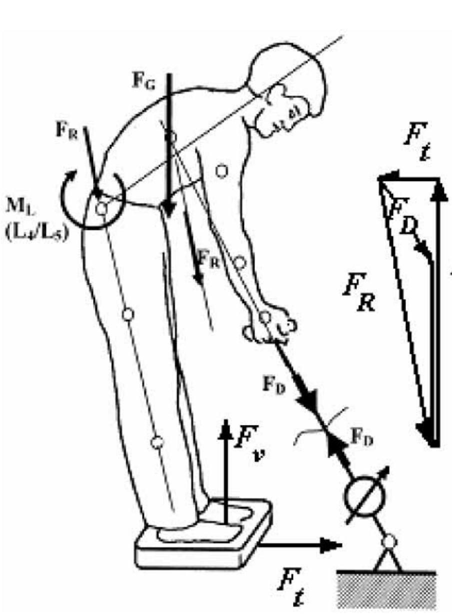

Figure 1. *Pulling force measurement.*

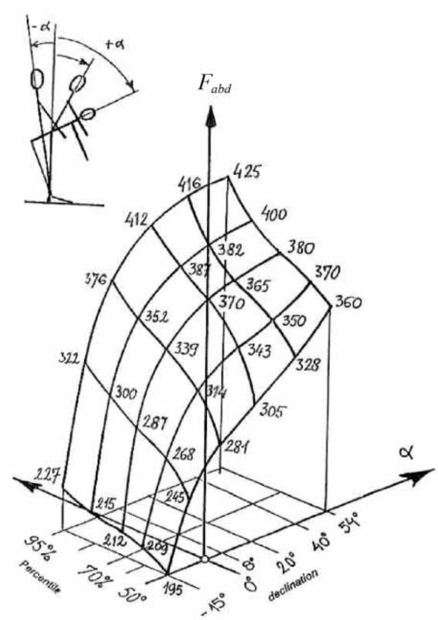

Figure 3. *Diagram of abdominal force, inclination and statistical distribution.*

anthropometry and photographically recorded postures. Using the regression formula of Donskij and Zatscijorskij (Lit 2.), the elements of the biomechanical model were determined.

From these measurements the 3-D diagram in Figure 3. was created which presents relations of the statistical distribution of height age and intra-abdominal force.

Intra-abdominal forces for this diagram were calculated from the values of reduced moments on L4/L5 point, because to this value of the moment there is corresponding IAP which could be represented with adequate force. Using the regression formula of Donskij and Zatscijorskij we determined the elements of the biomechanical model which were used in the calculation of respective lumbar moments.

When the supposed distribution of intra-abdominal forces for a subject of 32 years of age who is in erect posture at –15°, as shown in Figure 18, is a referent one, then it is possible to make a new diagram which represents the changes of intra-abdominal forces F_{abd} related to the trunk inclination and statistical distribution of the subject's standing height.

ISOKINETIC DEVICES AND DATA ANALYSIS

Short History. Isokinetic exercise and testing have been available since 1970. The concept was far from an immediate success. Isokinetic machines were few, with little or no feedback. The results were available with exercise as the only option. In the early 80's (around 1984) the world of isokinetics changed dramatically. Servo motors and microprocessors transformed the early machines into fast and dynamic tools offering instant data analysis and reproducibility. This meant that real time data became available and testing became as important as exercise.

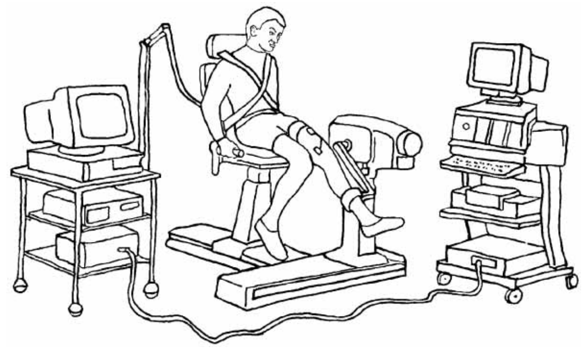

Figure 4. *Typical configuration of an isokinetic device.*

Isokinetic testing was originally a tool used mainly in exercise science and the only isokinetic movements available were concentric (with no thought given to isotonics, isometrics, continuous passive motion (CPM) or range of motion expansion). Eventually, isokinetics found its way into therapy albeit with very rigid machines usually specific to a joint or a small number of joints. New machines have now incorporated what we call today active dynamometry. It was at this stage that eccentric isokinetic testing and exercise became available. This change in the fundamental data collection process finally sparked large scale interest in isokinetic testing.

The term »isokinetic« refers to »constant velocity« and an isokinetic device which allows voluntary muscular contractions to be made at various pre-set (by the operator) joint velocities. This idea is in contrast to other resistance devices where joint velocity changes through motion.

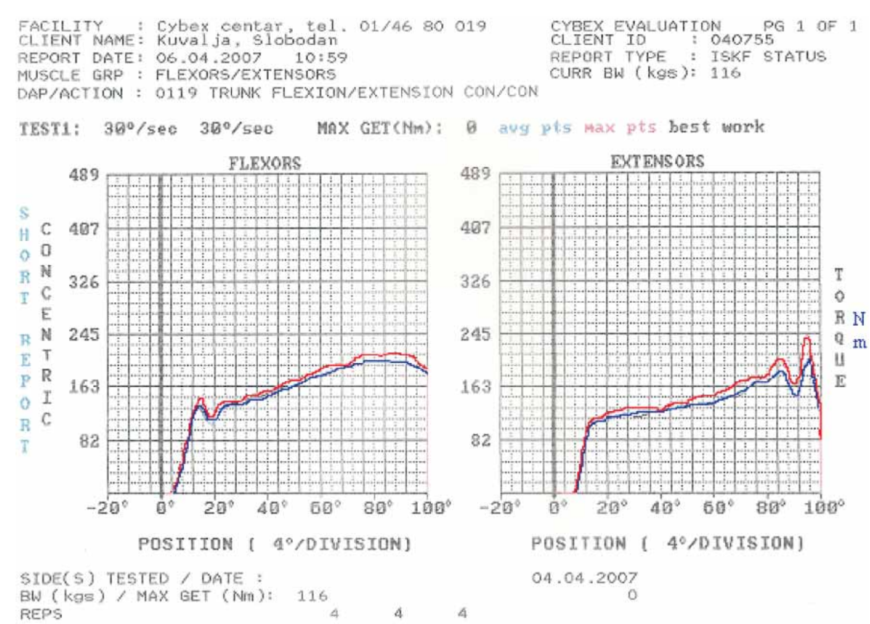

Figure 5. *Graphical presentation of results for trunk flexion/extension test.*

A typical isokinetic device (or dynamometer) has a number major components. The »hardware« consists of a seat (or »frame«) which allows the subject to be positioned in a specific position with considerable degree of reproducibility. Seat and back rest positions, angles of incline, relative positioning of limbs are standardized quite simply. Attached to the seat unit is the head assembly which houses the motor and/or servomotors responsible for the movement of the lever arm (or frame) and its various attachments. The hardware so described is usually linked to a control unit, which is effectively a computer loaded with appropriate controlling software and programs for data collection and storage.

One advantage of isokinetic testing is in providing numerous objective parameters that can be used to evaluate and analyze a patient's or athlete's performance. Isokinetic testing data that are frequently used to analyze muscular performance include peak torque, time rate of torque development, acceleration and deceleration, range of motion, total work, and average power.

For more specific details on various parameters and how to measure and interpret them which we cannot, because of limited space, give now and here, consult an isokinetic reference text e.g. Http://www.isokinetics.net. basics/basics2.htm. The following criteria are summarized in general terms for applying isokinetic test data:

RESULTS

FACILITY : Cybex centar, tel. 01/46 80 019 CYBEX EVALUATION PG 1 OF 1
CLIENT NAME: Kuvalja, Slobodan CLIENT ID : 040755
REPORT DATE: 06.04.2007 10:59 REPORT TYPE : ISKF STATUS
MUSCLE GRP : FLEXORS/EXTENSORS CURR BW (kgs): 116
DAP/ACTION : 0119 TRUNK FLEXION/EXTENSION CON/CON

SIDE(S) TESTED / DATE : 04.04.2007
BW (kgs) / MAX GET (Nm): 116 0
REPS 4 4 4

	CONCENTRIC FLEXORS		
SPEED(S) (deg/sec)	30	60	90
PEAK TORQUE (Nm)	216	183	195
PEAK TORQUE % BW	186%	157%	168%
ANGLE OF PEAK TORQUE	85	22	33
TORQUE @ deg			
TORQUE @ deg			
ACCEL TIME (sec)	0.03	0.05	0.11
TOTAL WORK (BWR) (J)	283	229	213
TOTAL WORK (BWR) % BW	243%	197%	183%
AVG POWER (BWR) (watts)	82	123	155
AVG POWER (BWR) % BW	70%	106%	133%
TAE (J)	4.5	7.6	10.8
ASD (Nm)	5	7	7
SET TOTAL WORK (J)	1108	906	784
ENDURANCE RATIO			
50% FATIGUE WORK (J)			
50% FATIGUE TIME (sec)			
50% FATIGUE REPS			
WORK RECOVERY RATIO			

	CONCENTRIC EXTENSORS		
SPEED(S) (deg/sec)	30	60	90
PEAK TORQUE (Nm)	243	224	160
PEAK TORQUE % BW	209%	193%	137%
ANGLE OF PEAK TORQUE	95	89	81
TORQUE @ deg			
TORQUE @ deg			
ACCEL TIME (sec)	0.03	0.03	0.05
TOTAL WORK (BWR) (J)	237	222	136
TOTAL WORK (BWR) % BW	204%	191%	117%
AVG POWER (BWR) (watts)	68	118	107
AVG POWER (BWR) % BW	58%	101%	92%
TAE (J)	6.6	9.5	6.3
ASD (Nm)	7	16	5
SET TOTAL WORK (J)	925	720	490
ENDURANCE RATIO			
50% FATIGUE WORK (J)			
50% FATIGUE TIME (sec)			
50% FATIGUE REPS			
WORK RECOVERY RATIO			

	RATIO AND ROM : FLEXORS/EXTENSORS		
PEAK TORQUE	88%	81%	121%
TORQUE @ deg			
TORQUE @ deg			
TOTAL WORK (BWR)	119%	103%	156%
AVG Power (BWR)	120%	194 %	144%

DISCUSSION AND CONCLUSIONS

Determination of intra-abdominal forces for all other age groups could be perforfmed by decreasing the respective force value of 212 N for a person of 32 years, multiplying it by the factor which could be calculated by dividing the value of abdominal force for a person (Figure 18.) that we analyzed, and that is of a certain age and belongs to determined percentile number. For example, a person of 50 years in the group of 70% has in diagram the intra-abdominal force of 183 N. The decreasing factor we mentioned above is k = 183 / 212 = 0.863. So, if we want to to know the intra-abdominal force of this 50 year old subject when he declines its trunk for, let say +20°, we should refer to the diagram (for 70% and +20° the force value of 370 N), and the calculated value of the force is 370 x 0.863 = 319.3 N.

In case of a female subject, the calculated intra-abdominal force should be decreased by of about 30%. This is valid in case of a female which also has 50 years and belongs to the group of 70% with the same inclination of the trunk, the intra-abdominal force of 319.3 x 0.70 = 223.5 N

Regarding from isokinetic measurements, it is evident that more results are achievable by means of an isokinetic device.

1. **equipment required:** Isokinetic testing equipment (e.g. Cybex)
2. **description / procedure:** The subject is positioned so that the body movement to be measured is isolated. The equipment is then set at different speeds and the force applied can be measured throughout the range of movement.
3. **results**: The results are often reported at different speeds so that speed/strength/power relationship can be seen. Comparison of the relative strengths of different sides of the body, or agonists versus antagonists (e.g. quads & hamstrings) can show specific muscular limitations.
4. **advantages**: Nearly any joint action can be tested by adjustment of the equipment.
5. **disadvantages:** The equipment required is bulky and expensive.
6. **comments**: These tests are often performed at universities as part of research projects, or as part of injury rehabilitation services.

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