

## Описательный обзор: динамометр для измерения мышц туловища

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*Обзорная статья*

**Аннотация:** Эффект сокращения мышц приводит к динамическому движению вращательных или статически стабилизирующих контактных сил [1] в зависимости от архитектуры сустава, а также организации мышц по отношению к осям движения. Из-за этого скелетные мышцы имеют элементарное значение в реализации всех физических движений.

Несмотря на значительную поддержку в повседневной жизни (поездка в машине), мышцы работают по-прежнему, они незаменимы во многих сферах сегодняшней жизни. Сила мышцы в том, что она может испытать стабильность, а также, изменения скорости. Однако подъем и переноска грузов также является частью профессиональной рутины многих мышц [2]. Мышечная сила также оказывает защитное действие на здоровье, так как возрастная потеря силы (саркопения) часто ассоциируется с уменьшением мышечного размера и функции [3, 4] - это может проявляться в снижении качества жизни [5, 6], снижении подвижности [2, 7] и повышенном риске падения у пострадавших пожилых людей [8].

В спорте ли, на работе или в укреплении здоровья - если улучшение ищется в одной из этих областей туловища - прочность и стабильность туловища имеют большое значение [9]. Текущий интерес проявляется в том, что туловище функционально является кинетическим звеном, способным передавать крутящийся момент между верхними и нижними конечностями [10]. В этом контексте здоровый и полностью функциональный позвоночник должен отвечать следующим требованиям: с одной стороны, должна быть высокая степень подвижности во всех сегментах и плоскостях движения позвоночника. С другой стороны, при динамических и статических нагрузках должна быть оптимальная и сбалансированная мышечная сила, и работоспособность мышц туловища и шеи [11]. В адекватном состоянии мышцы туловища соответственно способствуют правильному выполнению движений всего тела в рамках занятий спортом [12], профессиональной деятельностью, фитнесом и повседневной деятельностью [13].

Если же, с другой стороны, имеется мышечная недостаточность или дисбаланс в туловище, это может привести к проблемам в спортивной, профессиональной или повседневной деятельности пострадавших [14, 15] или к нарушениям здоровья [10, 16, 17].

Особое значение имеют проблемы со спиной и связанные с ними боли в спине. Уже в прежние годы Kraus et al. [18] пришел к выводу, что большинство болей в спине кроется в возникновении мышечной слабости мускулатуры туловища, что было подтверждено многими последующими исследованиями. Согласно Roy et al. [19] эта мышечная недостаточность вызывает более высокую нагрузку на пассивные тканевые структуры, что вызывает дегенеративные изменения, травмы и боли в спине. Для того, чтобы предотвратить боли в спине и серьезные травмы любого рода, а также лечить их целебно, необходима соответствующая силовая тренировка мышц спины. В дополнение к Паллок [20], многие другие исследования показали, что силовые тренировки для мышц туловища в течение длительного периода времени привели к увеличению изометрической максимальной прочности и дальнейшего снижения болевых симптомов.

В результате определена и количественная оценка силы туловища. Она позволяет получить представление о текущей производительности и здоровье человека [21], а также способность устанавливать, документировать и оценивать программы вмешательства [22]. Одной из возможностей опреде-

ления силы - как одной из основных характеристик двигателя - является измерение максимальной силы. Потому что "...максимальная сила — это размер, который описывает силовое свойство мышцы аналогично свойству показателей МПК, характеризующему выносливость" [2, р. 66]. Силовые динамометры, специально разработанные для этой цели, обычно пытаются определить генерируемые одно - и трехосные поясничные моменты мышц туловища и одновременно имитировать изометрические, изокинетические или другие мышечные действия [23].

Диагноз прочности туловища важен: поразителен тот факт, что до сих пор нет единого мнения в количественном определении оптимальных процедур и методов испытаний, которые будут использоваться [22].

В результате, в настоящее время существует множество различных диагностических аппаратов/устройств. В связи с этим настоящая работа направлена на то, чтобы дать обзор современных диагностических устройств. Описание самих устройств можно найти в представленной литературе.

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### Introduction

The contraction effect of muscles results in either dynamically moving rotational or statically stabilizing contact forces [1], depending on the joint architecture involved as well as the organization of the muscle courses in relation to the movement axes. Because of this, skeletal muscles are of elementary importance in the realization of all physical movements.

Even though numerous machines are a considerable support in everyday life, muscle work is still indispensable in many areas of life today. Muscle power is the prerequisite that both one's own body and objects can experience stability as well as speed changes. However, lifting and carrying loads is also part of the professional routine of many employed persons [2]. Muscle strength also has a protective effect on health, since age-related strength loss (sarcopenia) is often associated with reduced muscle size and function [3, 4] - this can manifest itself in a diminished quality of life [5, 6], reduced mobility [2, 7], and an increased risk of falling in the affected older adults [8].

Whether in sport, at work or in health promotion - if an improvement is sought in one of these areas - trunk strength and stability are of great importance [9]. The current interest is evident insofar as the trunk is functionally a kinetic link that can transmit torque between the upper and lower extremities [10]. In this context, a healthy and fully functional spine must meet the following

requirements: On the one hand, there must be a high degree of mobility in all segments and planes of motion of the spine. On the other hand, under both dynamic and static loads, there must be optimal and balanced muscle strength and performance of the trunk and neck muscles [11]. In an adequate condition, the trunk muscles accordingly promote the proper execution of whole-body movements within the performance of sports [12], professional activities, fitness and everyday activities [13].

If, on the other hand, there is muscular insufficiency or imbalance in the trunk, this can lead to problems in the athletic, occupational or everyday performance of those affected [14, 15] or to health impairments [10, 16, 17].

Especially back problems and associated back pain are of particular importance. Already in earlier years Kraus et al. [18] has the conclusion that the majority of back pain lies in the origin of muscular weakness of the trunk musculature, which was confirmed by many subsequent studies. According to Roy et al. [19] this muscular insufficiency causes a higher load on the passive tissue structures, which causes degenerative changes, injuries and pain in the back. In order to prevent back pain and serious injuries of any kind as well as to treat them curatively, a corresponding strength training of the back muscles is indispensable. In addition to Pullock's [20], many other studies have shown that strength training of the trunk muscles over a longer period of time has led to an increase in isometric maximum strength and a further reduction in pain

symptoms.

As a result the determination and quantification of torso strength provides insight into the current performance and (back) health of an individual [21], as well as the ability to establish, document and evaluate intervention programs [22]. One possibility to determine force - as one of the basic motor characteristics - is the measurement of maximum force. Because "...the maximum force is a size which describes the force property of the muscle in a similar way to the VO<sub>2</sub>max which characterizes the endurance property" [2, p. 66]. Force dynamometers specially developed for this purpose usually try to determine the generated one-to three-axis lumbar moments of the trunk muscles and at the same time simulate the isometric, isokinetic or other muscle actions [23].

The diagnosis of trunk strength is important: astonishing is the fact that there is



still no consensus in quantifying the optimal test procedures and methods to be used [22]. As a result, there are currently numerous different diagnostic apparatuses/devices. On the occasion of this diversity and lack of transparency, the present work with the following overview aims to give an overview of current diagnostic devices.





### Methods




In the databases PubMed, BASE and LIVIVO a literature search was carried out with the following keywords: back OR lumbar OR trunk OR core AND strength AND analysis OR performance. All studies were considered that carried out an instrument-based trunk force measurement. Later in the process these dynamometers were integrated into an overview table. In addition, further dynamometers are listed which were found exclusively via the search engine Google.


### Results


Table 1 - Display of a selection of devices.


Dynamometers (pictorial sources: retrieved 6. November 2018)	Parameters	Sources
BfMC CTT Pegasus 	Unit Form of contraction Planes	Nm isometric trunk extension/flexion trunk rotation trunk lateral flexion additional: ROM-Training
<a href="http://www.bfmc.info/eng/index.php?cs=4-2">http://www.bfmc.info/eng/index.php?cs=4-2</a>	Position	sitting
BfMC CTT Kolossos 	Unit Form of contraction Planes	Nm isometric trunk extension/flexion trunk rotation trunk lateral flexion
<a href="http://www.bfmc.info/eng/index.php?cs=4-4">http://www.bfmc.info/eng/index.php?cs=4-4</a>	Position	sitting


BfMC CTT Minotaur	Unit	Nm	[3]
	Form of contraction	isometric	
	Planes	cervical extension/ flexion cervical lateral flexion trunk extension/flexion trunk rotation trunk lateral flexion	
<a href="http://www.bfmc.info/eng/index.php?cs=4-8">http://www.bfmc.info/eng/index.php?cs=4-8</a>	Position	sitting	
Biodex Sytem4 Pro	Unit	Nm	[4]
	Form of contraction	concentric/ eccentrically/isometric	[5]
	Planes	trunk extension/flexion	[6]
		modularly expandable:	[7]
		ankle, knee, shoulder, elbow, wrist and hip	[8]
	Position	sitting	[9]
<a href="https://www.proxomed.com/de/produkte/biodex_system_4_pro-60.html">https://www.proxomed.com/de/produkte/biodex_system_4_pro-60.html</a>			[10]
CITEC hand-held dynamometer	Unit	N	[12]
	Form of contraction	isometric	[13]
	Planes	arbitrary	[14]
	Position	arbitrary	
			[15]
<a href="http://citec.nu/frm/uk.htm">http://citec.nu/frm/uk.htm</a>			[16]
CSMi Cybex Norm Isokinetic Dynamometer	Unit	Nm	[18]
	Form of contraction	dynamic	[19]
	Planes	trunk extension/flexion	[20]
	Position	standing	[21]
<a href="http://cdn.intechopen.com/pdfs/36700/InTech-Muscular_performance_assessment_of_trunk_extensors_a_critical_appraisal_of_the_literature.pdf">http://cdn.intechopen.com/pdfs/36700/InTech-Muscular_performance_assessment_of_trunk_extensors_a_critical_appraisal_of_the_literature.pdf</a>			[22]
			[23]

David	Unit	kg	[24]
Form of contraction		dynamic	[25]
Planes		consisting of six devices: cervical extension/ flexion cervical rotation cervical lateral flexion trunk extension/flexion	[26]
			
<a href="https://www.davidhealth.com/solution/spine-solution/">https://www.davidhealth.com/solution/spine-solution/</a>		trunk rotation	
	Position	trunk lateral flexion	
		sitting	
DIERS myoline professional	Unit	N	[27]
Form of contraction		isometric	[28]
Plane		cervical extension/ flexion cervical lateral flexion trunk extension/flexion trunk rotation trunk lateral flexion	
			
<a href="https://diers.eu/de/produkte/muskelkraftmessung/diers-myoline/">https://diers.eu/de/produkte/muskelkraftmessung/diers-myoline/</a>		additional:	
		knee extension/flexion	
		hip adduktion/ abduktion	
		elbow extension/flexion	
		shoulder external rotation/internal rotation	
	Position	sitting	
DigiMax ISO-Check	Unit	kg	[29]
Form of contraction		isometric	
Planes		cervical extension/ flexion cervical lateral flexion trunk extension/flexion trunk rotation trunk lateral flexion	
			
<a href="http://www.digimax-systems.de/index.php/de/produkte/iso-check">http://www.digimax-systems.de/index.php/de/produkte/iso-check</a>		additional:	
		knee extension/flexion	
		butterfly/butterfly reverse	
	Position	sitting	





DigiMax Iso-CheckMobil	Unit	kN	[30]
	Form of contraction	isometric	
	Planes	trunk extension/flexion trunk rotation trunk lateral flexion additional: knee extension/flexion pressure and traction of upper extremities	
	Position	sitting	
<a href="http://www.digimax-systems.de/index.php/de/produkte/iso-checkmobil">http://www.digimax-systems.de/index.php/de/produkte/iso-checkmobil</a>			

Dr. Wolff BackCheck 607	Unit	kg	[31]
	Form of contraction	isometric	
	Planes	cervical extension/flexion cervical lateral flexion trunk extension/flexion trunk lateral flexion additional: pressure and traction of upper extremities	
	Position	standing	
<a href="https://www.dr-wolff.de/trainings-diagnostik.html#trainings-diagnostik">https://www.dr-wolff.de/trainings-diagnostik.html#trainings-diagnostik</a>			

D&R IsoMed 2000 Back Modul	Unit	Nm	[32]
	Form of contraction	concentric/ eccentrically/isometric	[33]
	Planes	trunk extension/flexion additional: modularly expandable	[34]
	Position	sitting	
<a href="http://www.isomed2000.de/downloads/TDat_BM_Eng.pdf">http://www.isomed2000.de/downloads/TDat_BM_Eng.pdf</a>			

Ergo-Fit Torso Check	Unit	Nm	[35]
	Form of contraction	isometric	
	Planes	trunk extension/flexion trunk rotation trunk lateral flexion	
	Position	sitting	
<a href="https://www.ergo-fit.de/ergo-fit/produkte/torso-line/torso-check/">https://www.ergo-fit.de/ergo-fit/produkte/torso-line/torso-check/</a>			



Hoggan MicroFET®2	Unit	lbs/N/kgf	[36]
	Form of contraction	isometric	[37]
		dynamic	[38]
	Planes	arbitrary	[39]
		MicroFET 3 additionally measures the range of motion (inclinometer)	[40]
	Position		arbitrary
<a href="https://hogganscientific.com/product/microfet2-muscle-tester-digital-handheld-dynamometer/">https://hogganscientific.com/product/microfet2-muscle-tester-digital-handheld-dynamometer/</a>	Unit	/	
HubEX LEX	Form of contraction	/	[43]
		Planes	lumbar extension/ flexion
	Position	supine	
	<a href="https://www.komachine.com/en/company/daeyang-mechanics-hubex/detail/">https://www.komachine.com/en/company/daeyang-mechanics-hubex/detail/</a>	Unit	/
Isostation B-200	Form of contraction	dynamic	[45]
		Planes	isometric
	trunk extension/flexion additional: isoinertial felxion- repetition test		[47]
		Position	standing
<a href="http://cdn.intechopen.com/pdfs/36700/InTech-Muscular_performance_assessment_of_trunk_extensors_a_critical_appraisal_of_the_literature.pdf">http://cdn.intechopen.com/pdfs/36700/InTech-Muscular_performance_assessment_of_trunk_extensors_a_critical_appraisal_of_the_literature.pdf</a>	Unit	kg	
JTECH Medical Commander Echo MMT	Form of contraction	isometric	[49]
		Planes	arbitrary
	Position	arbitrary	[51]
	<a href="https://www.jtechmedical.com/shop-now/Commander-Echo-Muscle-Testing-Starter-Kit-p89053317">https://www.jtechmedical.com/shop-now/Commander-Echo-Muscle-Testing-Starter-Kit-p89053317</a>		Unit
Lafayette Instrument Modello1165			



<http://lafayetteevaluation.com/products/lafayette-hand-held-dynamometer>

MedX lumbar extensor



<https://www.medxonline.de/trainingsgeraete/erhaltliche-stationen/le-lumbar-extension/>

Physiomed Con-trex TP 500



<https://www.physiomed.de/produkte/con-trex-tp-500/>




Form of contraction	isometric	[53]
Planes	arbitrary	
Position	arbitrary	

Unit	lb	[54]
Form of contraction	dynamic	[55]
	isometric (at seven angles of trunk flexion)	[56]
Planes	lumbar extension/flexion	[57]
Position	sitting	

Unit	Nm	[58]
Form of contraction	concentric/excentrically/isometric	[59]
Planes	trunk extension/flexion	[60]
Position	standing	

Proxomed Tergumed 710	Unit	Nm	[61]
	Form of contraction	isometric (strength diagnostic)	
		dynamic (feedback training)	
	Planes	consisting of five devices:	
		cervical extension/flexion	
		cervical rotation	
		cervical lateral flexion	
<a href="http://www.soreha.net/Home/nav/134/id/62.html">http://www.soreha.net/Home/nav/134/id/62.html</a>		trunk extension/flexion	
		trunk rotation	
		trunk lateral flexion	
	Position	sitting	



<p>Schnell 4back-Paket Professional</p>  <p><a href="https://www.schnell-online.de/de/produkte-detail/13-4back-professional/453-4back-paket-professional/?prevId=97">https://www.schnell-online.de/de/produkte-detail/13-4back-professional/453-4back-paket-professional/?prevId=97</a></p>	<p>Unit</p> <p>Form of contraction</p> <p>Planes</p> <p>Position</p>	<p>Nm</p> <p>isometric (strength diagnostic) dynamic (feedbacktraining) consisting of four devices: trunk extension/flexion trunk rotaion trunk lateral flexion sitting</p>	<p>[62]</p>
<p>Stolzenberg Dynamed Iso-Check</p>  <p><a href="https://stolzenberg.org/site/de/product.php?id=107">https://stolzenberg.org/site/de/product.php?id=107</a></p>	<p>Unit</p> <p>Form of contraction</p> <p>Planes</p> <p>Position</p>	<p>kg</p> <p>isometric trunk extension/flexion trunk rotation trunk lateral flexion additional: knee extension/flexion elbow extension/flexion hip adduktion/ abduktion shoulder external rotation/internal rotation sitting</p>	<p>[63]</p>
<p>Takei T.K.K.5402 BACK D</p>  <p><a href="http://www.takei-si.co.jp/en/productinfo/detail/50.html">http://www.takei-si.co.jp/en/productinfo/detail/50.html</a></p>	<p>Unit</p> <p>Form of contraction</p> <p>Planes</p> <p>Position</p>	<p>kgf (kilogram-force)</p> <p>isometric sagittal standing</p>	<p>[64] [65] [66] [67]</p>

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