Heliyon 7 (2021) e07827

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Adaptive Force and emotionally related imaginations – preliminary results suggest a reduction of the maximal holding capacity as reaction to disgusting food imagination

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ARTICLE INFO

Keywords:
Adaptive Force
Isometric Adaptive Force
Holding capacity
Holding isometric muscle action
Imaginations
Emotions
Motor control
Functional weakness
Manual muscle test

ABSTRACT

The link between emotions and motor control has been discussed for years. The measurement of the Adaptive Force (AF) provides the possibility to get insights into the adaptive control of the neuromuscular system in reaction to external forces. It was hypothesized that the holding isometric AF is especially vulnerable to disturbing inputs. Here, the behavior of the AF under the influence of positive (tasty) vs. negative (disgusting) food imaginations was investigated. The AF was examined in $n = 12$ cases using an objectified manual muscle test of the hip flexors, elbow flexors or pectoralis major muscle, performed by one of two experienced testers while the participants imagined their most tasty or most disgusting food. The reaction force and the limb position were measured by a handheld device. While the slope of force rises and the maximal AF did not differ significantly between tasty and disgusting imaginations ($p > 0.05$), the maximal isometric AF was significantly lower and the AF at the onset of oscillations was significantly higher under disgusting vs. tasty imaginations (both $p = 0.001$). A proper length tension control of muscles seems to be a crucial functional parameter of the neuromuscular system which can be impaired instantaneously by emotionally related negative imaginations. This might be a potential approach to evaluate somatic reactions to emotions.

1. Introduction

The phenomenon of functional weakness has been discussed in neuropsychiatry for decades. Its etiology still remains unclear because it appears without existing neuropathology or other organic diseases [1]. Functional weakness usually shows different forms of regional distribution of weakened muscles over the body: hemiparesis (63%); monoparesis (16%); triparesis (3%); paraparesis (10%); and tetraparesis (8%) [2]. Compared to controls, functional weakness is significantly more frequent accompanied by other physical complaints like irritable bowel syndrome (36% vs. 18%) and chronic back pain (40% vs. 16%) [3]. Moreover, the same occurs regarding undergone surgery like hysterectomy, appendectomy, and cholecystectomy [3]. There are also some socio-psychological factors experienced in childhood which are discussed as a possible predisposing causation for persons who developed functional weakness during adulthood. Selfreported sexual abuse (13% vs. 1% in controls, $p = 0.002$) or physical neglect (21% vs. 7%, $p = 0.009$) turned out to be more frequent in the history of affected persons [3]. Furthermore, significantly more participants with functional weakness reported affective disorders (as minor depression, mixed anxiety and depression, cyclothymic disorder) (61% vs. 11%, $p < 0.0001$) or major depressions (32% vs. 7%, $p < 0.001$) [1]. Functional weakness frequently appears suddenly after psychological or also physiological traumatic events, but it can also arise years or even decades after early socio-psychological stress [2]. In the latter a subclinical status can be assumed before the weakness finally becomes clinically apparent. It is hypothesized that a refined assessment of the adaptive function of sensorimotor control could possibly uncover a hidden insidious process prior to manifestation. That would be of great importance because in many cases, functional weakness evolves into a long-term health issue. A review included five studies which reported follow up data of patients with functional weakness and revealed variable results regarding the prognosis. After follow-up durations of 0.5–12.5 years, the percentage of persons with persisting same or even worse symptoms ranged from 14% to 56% or 0%–69%, respectively [4]. A complete remission was reported in 50–78% [4]. Psychological items like hopelessness and personality disorders were correlated with a more adverse prognosis [4].

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https://doi.org/10.1016/j.heliyon.2021.e07827
Received 20 May 2021; Received in revised form 28 June 2021; Accepted 16 August 2021

The connection of mind and body has been suggested for decades [5, 6]. Thereby, the research field of psychoneuroimmunology was established [6]. Pert stated "that virtually all illness, if not psychosomatic in foundation, has a definite psychosomatic component" [5]. Due to this mind-body connection and neurophysiological considerations (see below), it is conceivable that also the motor output might reflect emotional regulation.

The above mentioned refined assessment is based on the concept of Adaptive Force (AF) which was introduced by the research group around Bittmann [7, 8, 9, 10, 11]. The AF is defined as the neuromuscular function which is necessary to maintain a given position or movement despite an external force impact. By performing the AF, the motor output must be permanently adapted according to the sensory input induced by the external load. This requires a sound functioning of the complex sensorimotor control. One specific way to measure the AF is to hold a given position against a rising external load. In case the load surpasses the holding capacity, the maximal isometric Adaptive Force ($AFiso_{max}$) is exceeded and the involved muscles merge into eccentric action. Thereby, the muscle's force increases further up to its maximum ($AFecc_{max}$). It has been shown that the maximal holding capacity ($AFiso_{max}$) is normally lower (~80%) than the maximal strength of a muscle [11]. This behavior and additional hints [12, 13] suggest the ability to hold could be an independent quality of neuromuscular function. Moreover, the maximal holding AF ($AFiso_{max}$) seems to be more variable and possibly vulnerable regarding interfering influences like pleasant or unpleasant olfaction [10]. This may be due to the nature of neurophysiological motor control during a holding action [12, 13]. In contrast to pushing against a stable counterfort, the holding isometric muscle action (HIMA) requires proper adaptability especially with regard to a varying external load. In this process, in particular the cerebellum appears to work as a kind of forward controller in collaboration with the inferior olivary nucleus (ION) [14, 15]. As part of the error processing, the olivocerebellar circuitry provides a rhythmic neuronal signal to enable temporal coordinated movements [16]. Other central structures like, e.g., the thalamus, the basal ganglia and the cingulate cortex of the limbic system are also involved [17, 18, 19, 20, 21, 22]. Besides, nociception [23], olfaction [24] and emotions [25, 26, 27] are fed into those regulatory loops. Sagaspe et al. have shown that fear modulates motor responses via the amygdala, the lateral orbitofrontal cortex and supplementary motor areas [25]. The tight linkage between emotions and motor control is also represented in the cingulate cortex. Regarding its anterior part it was reported by Vogt et al. that "Emotional states are closely related to effector processes insofar as every emotion achieves expression through autonomic, endocrine, and skeletomotor outflow…" [26].

In patients with functional weakness, inter alia, hand grip strength is measured [28]. From the perspective of AF measurements, a hand grip dynamometer seems to be inappropriate, since thereby, the fingers of the closed hand are pressing against a grip. This is not a holding but a pushing isometric action. Therefore, it might neglect the most important aspect of the Adaptive Force – holding in an adaptive way. The AF can be measured by a pneumatically driven system [11] as well as utilizing a manual muscle test (MMT). Basically, two different appraoches are in use for the MMT [29]. The so called "make test" stands for a MMT during which the participant pushes actively against the tester who provides a fixed resistance. In contrast, during the "break test" the participant has to hold against the increasing pushing action applied by the examiner [29]. The break test is related to the assessment of the holding ability in the sense of AF. Although there are advantages of the MMT in clinical practice like quickness and flexibility its main disadvantage lies in its subjective nature regarding force development and rating. Therefore, measurements are needed to determine the AF during the MMT objectively. For this reason, a mobile handheld device was invented and constructed in the Neuromechanics Laboratory of the University of Potsdam in collaboration with industrial partners. It allows to link the clinical advantages of the MMT with the objectivity of a measuring device [8]. To detect the maximal isometric adaptive holding capability ($AFiso_{max}$) the force has to be identified exactly at the moment when the limb starts to give way (breaking point). Therefore, not only the force between examiner and participant but also the limb position have to be measured simultaneously. The mentioned handheld device is appropriate for those purposes and was used for the present study.

This pilot study aims to investigate whether the manually assessed AF shows different behaviors under the influence of tasty or disgusting food imaginations in healthy participants. Since negative imaginations are considered to cause negative emotions [30] (disgust), we presume an inhibitory effect on the motor output. We assume outcomes comparable to those of a similar pilot study concerning the influence of positive and negative experienced odors [10]. Based on those previous findings, it is hypothezised the $AFiso_{max}$ is reduced by disgusting vs. tasty imaginations. Stable isometric conditions are characterized by mechanical oscillations. Therefore, we hypothesize, furthermore, that during disgusting imaginations, in case the muscle gets unstable as proposed above, the oscillations will appear if at all on a high force level. Furthermore, it is assumed that the maximal AF (AFmax) will not be affected by negative imaginations. The presented study might give new insights into the reaction of motor control and emotionally related imaginations and could provide a novel approach of assessing the adaptive motor control to detect a possible influence of emotional stress on the neuromuscular function.

2. Methods

Since this method is similar to the one described in Schaefer et al (2021) [10], the following descriptions are partly adopted.

2.1. Participants

The AF of the hip or elbow flexors or of the sternal part of the pectoralis major muscle of n = 10 healthy participants was measured by using a handheld device, which recorded the dynamics and kinematics during the manual muscle test (MMT). The MMTs were performed by one of two experienced testers (tester 1: female, 34 yrs, 168 cm, 55 kg; MMT experience: 8 yrs; tester 2: male, 63 years, 185 cm, 87 kg; MMT experience: 25 yrs). In two participants two muscles were examined. Table 1 shows the anthropometric data of the participants. Any type of complaints or health issues and an affected neuromuscular function of the tested muscles determined by the MMT prior to the measurements were defined as exclusion criteria.

The study was done according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the University of Potsdam, Germany (protocol code 35/2018; 17.10.2018).

2.2. Handheld device for recording the Adaptive Force

The handheld device (development was funded by the Federal Ministry of economy Affairs and Energy; project no. ZF4526901TS7) was already used in Bittmann et al. [8] and Schaefer et al. (2021) [10]. It consists of strain gauges (co. Sourcing map, model: a14071900ux0076, precision: 1.0 ± 0.1%, sensitivity: 0.3 mV/V) and kinematic sensor technology (Bosch BNO055, 9-axis absolute orientation sensor, sensitivity: ±1%) to record the reaction force, the accelerations and angular velocity (gyrometry) during the MMT. All data were AD converted, buffered with a sampling rate of 180 Hz and sent via Bluetooth 5.0 to a notebook. A measuring software stores the transmitted data.

2.3. Manual muscle testing

The manual muscle testing was described previously in Schaefer et al. (2021) [10] and should only be briefly scatched here. The MMT is a clinical method of testing the AF as a marker of neuromuscular functioning [8, 10, 29]. In the present investigation, the "break test" was utilized to perform the MMT [8, 10, 29]. Thereby, the tester pushes

Table 1. Anthropometric data. Arithmetic means (M) and standard deviations (SD) of age, height and body mass of all healthy participants (n = 10) are given.

Gender	Age (yrs.)	Height (cm)	Body mass (kg)
Female (n = 7)	39.00 ± 17.49	165.10 ± 3.44	63.71 ± 11.76
Male (n = 3)	35.67 ± 22.81	185.30 ± 5.51	84.00 ± 4.00

against the participant's limb with an increasing force, whereby the participant tries to hold the limb's preset position as stable as possible. The MMT examines the stability of the muscle length during an applied external force increase throughout a range up to a considerably high level. Therefore, the AFmax does regularly not refer to the maximal strength of the participant. It represents the force which is maximally applied to the participant and which can be maintained during interaction. The maximally achieved force on the tester side is limited by the given testing position and the maximal strength of the tester. In previous measurements, the two included testers reached maximal forces of ~280 N in the test position of the MMT of the hip flexors against a stable resistance [8]. Thereby, they were asked to apply a force increase as if they would test a young athletic male participant.

The rating of the MMT by the tester differentiates between dichotomous conditions [8, 10, 29]: “Stable” = the limb of the participant maintains the isometric position during the whole force increase. “Unstable” = the limb of the participant yields during the force rise (breaking point). Measuring force and limb position simultaneously using the newly developed handheld device enables an objectification of the usually subjective MMT. One prerequesite for the present investigation is the capability of the testers to perform the MMT in a reproducible way. Both testers proved this ability prior to the study (for more detailed information see Bittmann et al. [8]).

The profile of force application during the MMT was described in Bittmann et al. [8] and should have the course as depicetd in Figure 1. The decisive phase is the second one, at which the neuromuscular control is especially challenged because of the exponential force increase.

2.4. Setting and procedure

The participants were introduced to the procedure and gave their written informed consent to participate. Afterwards, the hip flexor group was tested by an initial MMT. In case of assessing it as fully “stable”, the MMT of hip flexors was selected for the measurements. In case it did not meet this requirement, the elbow flexors or pectoralis major muscle were used provided full stability. Afterwards, each participant was asked to designate (1) a food which he or she loves and classifies as “delicious” (tasty) and (2) a food which is felt and experienced before as “disgusting” (disgusting). The rating scale ranged from -5 (disgust) to +5 (tasty). Only foods which were rated as -5 or +5 were chosen for imagination. Since this rating is highly individual and subjective, the participants naturally showed different preferences or aversions. Food rated as delicious (+5) ranged from cake, fruits or noodles and from spinach, seafood to blood sausage perceived as disgusting (-5). The participants described, e.g., that it is disgusting to see the blood and taste the iron-like flavor of the blood sausage. Furthermore, the imaginations were often accompanied by past positive or negative experiences. For example, one participant told that he was forced to eat spinach in kindergarten until he had to gag. Reversely, some participants reported on the delicious apple pie of the grandma (inlcuding a positive connection to the grandma) or the freshness of a watermelon which is related to summer and positive emotions. This reflects the highly individual character of imaginations perceived as disgusting or pleasurable and the connection to the formerly experienced emotional situations.

Subsequently, the participant's AF was recorded with the handheld device during the MMT executed by the same tester while the participant imagined its personal culinary experience: 3 x disgusting, followed by 3 x tasty. For that, the participant was verbally introduced to the imagination by an assistant giving a few keywords describing the food. The participant was asked to imagine the food experience as realistic as possible perceiving intensively the disgust or culinary pleasure with all senses (taste, smell, optics, mouthfeel, texture, …). This imagination lasted for ~20s and the participant was asked to stay in the imagination during the MMT. The resting period between the MMTs was ~60s.

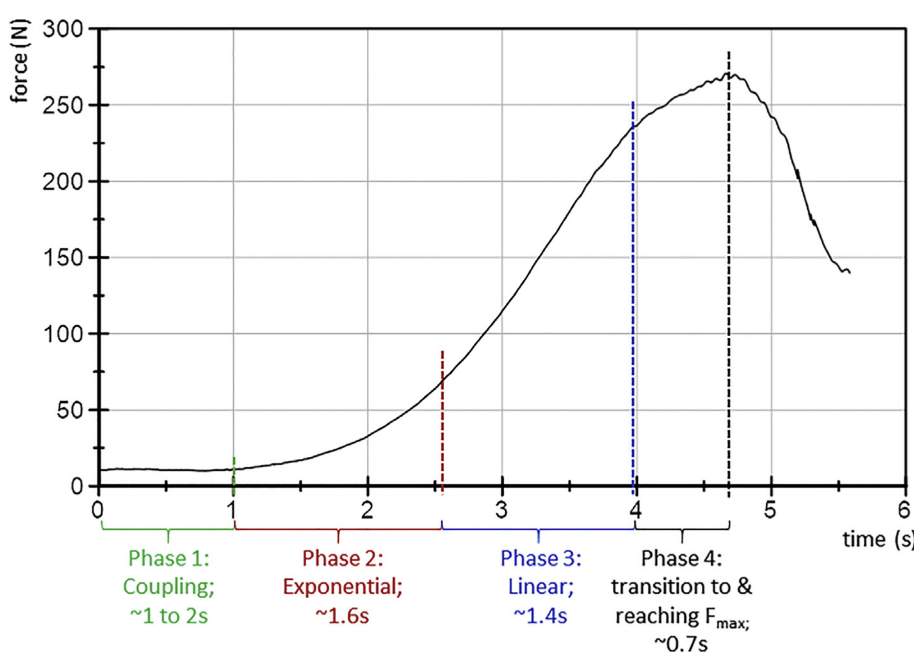

Figure 1. Schematic force profile. The force increase applied externally by the tester during the manual muscle test consists of the four illustrated phases (according to Bittmann et al. [8]).

Tester 1 tested n = 7 muscles of six participants (5 x hip flexors, 1 x elbow flexors, 1 x pectoralis) and tester 2 tested n = 5 muscles of four participants (2 x hip flexors, 1 x elbow flexors, 2 x pectoralis).

The setting was similar to the one described in Schaefer et al. (2021) [10]: The handheld device (Figure 2A) was placed between the palm of the tester and the limb of the participant to measure the dynamics and kinematics during the MMT. For all muscle tests, the participant lay in supine position on an examination table. For the hip flexors, the angles of hip and knee were 90° (Figure 2B). The tester had contact to the distal end of the thigh of the participant. For the elbow flexors, the elbow joint was positioned in 90° with a maximal supination and with a shoulder abduction of 0° (Figure 2C). The tester applied the force via the handheld device at the distal forearm of the participant. For testing the pectoralis major muscle, the maximally extended arm was positioned in 90° anteversion, 0° adduction and maximal internal rotation Figure 2D. The tester contacted the forearm using the handheld device. In all three settings, the placement of the device at the corresponding limb was marked exactly to reproduce the test position in all trials precisely. The force application by the tester was performed perpendicular to the respective limb in direction of muscle lengthening.

In all MMTs, the participant's task was to maintain the given starting position isometrically as long as possible during the adaptation to the external force increase applied by the tester. The handheld device measured the reaction force and the limb position (angle, angular velocity). Additionally, the tester rated the subjectively felt stability during the MMT ("stable" = 1, "unstable" = 0).

2.5. Data processing and statistical analysis

The analyses were performed according to Schaefer et al. (2021) [10]. The force and gyrometer signals were analyzed in DIAdem 2020 (National Instruments). All signals were interpolated (linear spline interpolation) to generate equidistant time channels (1000 Hz) and were filtered (Butterworth, cut-off frequency 20 Hz, filter degree 5). The following parameters were evaluated:

2.5.1. The maximal Adaptive Force (AFmax)

The AFmax (N) stands for the maximal force value of the whole trial. AFmax can be obtained under two conditions. In case the muscle length remains stable during the whole force increase, AFmax arises under isometric conditions ($AFiso_{max}$). If the muscle gives way during the force rise, AFmax is reached during eccentric muscle action ($AFecc_{max}$). During stable MMT, the AFmax does not necessarily represent the maximal strength of the participant, since it depends also on the force level exerted by the tester. In case of unstable MMTs, the AFmax is defined by the participant's $AFecc_{max}$, which refers to the maximal eccentric adaptive capacity of the participant under those circumstances.

2.5.2. The maximal isometric Adaptive Force ($AFiso_{max}$)

This parameter refers to the maximally reached AF under holding isometric conditions. Hence, until this point no muscle lengthening arose. To determine the breaking point, which indicates the start of muscle lengthening, the gyrometer signal was utilized. Under isometric circumstances, it oscillates around zero. In case the muscle does not lengthen throughout the entire MMT, the maximal force value is AFmax = $AFiso_{max}$. If the muscle yields, the gyrometer signal decreases below zero. In that case, $AFiso_{max}$ (N) is defined as the force value at the moment of last zero crossing of the gyrometer signal, which indicates an angle deviation over time. The parameters $AFiso_{max}$ and the ratios of $AFiso_{max}$ to AFmax (%) as well as to the total maximal of all AFmax values (maxAFmax) (%) – irrespective if measured during tasty or disgusting imaginations – were used for further considerations. The ratio including the maxAFmax was chosen since the maximal of all AFmax values is closest to the maximal strength of the participant. It has to be considered that the maxAFmax value was obtained either during isometric or during eccentric muscle actions.

2.5.3. The Adaptive Force at the moment of onset of oscillations (AFosc)

In some trials, oscillations appeared in the force signal in the course of force increase and, thus, those were evaluated in NI DIAdem 2020. The onset of oscillations was defined if four sequential maxima in the force signal were present with a time distance of $dx < 0.15$ s. The threshold of 0.15 s was chosen because muscles oscillate mechanically with frequencies ~ 10 Hz [31, 32, 33, 34]. AFosc (N) refers to the force value of the first of those oscillations. In case no oscillatory onset was present, AFosc = AFmax. The parameters AFosc and the ratios of AFosc to AFmax (%) as well as to maxAFmax (%) were used for further considerations.

2.5.4. Slope of force rise

The slope of the force signal was compared between the trials under tasty vs. disgusting imaginations to examine a possible influence of an inappropriate force rise. For that, the force values of 70% and 100% of the $AFiso_{max}$ of the as unstable assessed MMTs served as reference (average of all unstable trials of one participant). The slope was then calculated by the difference quotient of the force values and the respective time points. Those values were transformed by the decadic logarithm since the force rise was exponential. The logarithmized slope is provided in lg(N/s). In four as stable and in one as unstable assessed

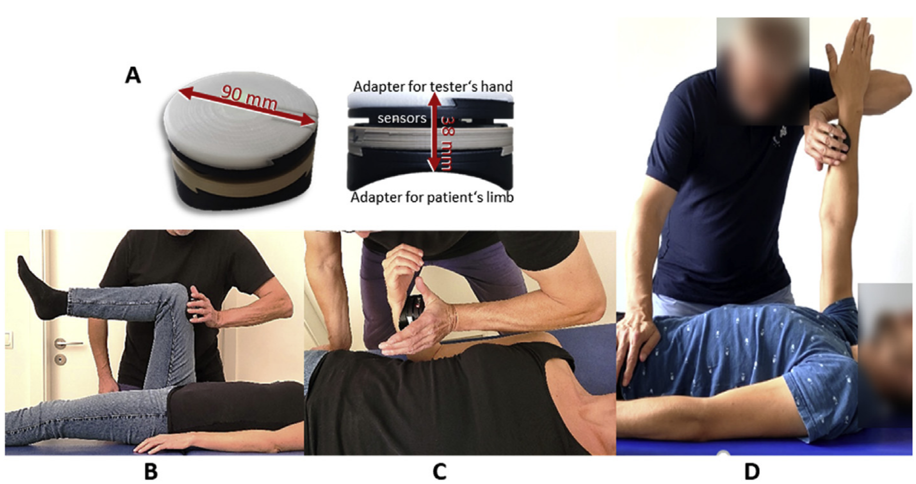

Figure 2. Setting of the measurements of Adaptive Force. The handheld device (A) is placed between the palm of the tester and the limb of the participant. The starting positions of the manual muscle tests (MMT) of (B) the hip flexors, (C) the elbow flexors and (D) the sternal part of the pectoralis major muscle are displayed. The MMTs were performed while the participant imagined either tasty or disgusting food. (modified according to Schaefer et al. (2021) [8]).

trials, the reference value of 100% of $AFiso_{max}$ of unstable MMTs emerged during the transition to phase 4. To avoid a distortion, those trials were excluded from the slope evaluation.

For statistics, the arithmetic means (M), standard deviations (SD) and coefficient of variation (CV) of all parameters were calculated for each imagination of each participant. One participant showed a basically different behavior in her tested hip and elbow flexors (3 and 5 trials, respectively), especially concerning the AFmax during unstable MMTs (for details see below). This created a statistical outliar. Since this case might be seen as a specific quality of motor regulation, it was considered separately as a special case and was excluded from the following evaluation.

Statistical analyses included the calculation of the 95% confidence intervals (CI) for the remaining n = 10 cases out of 9 participants concerning tasty and disgusting imaginations. The further statistical analyses were done using IBM SPSS Statistics 27. The normal distribution, checked by the Shapiro Wilk test, was fulfilled for all parameters. The differences between the trials under tasty and disgusting imaginations were investigated by the t-tests for paired samples. The effect size was calculated by Cohen's $dz = \frac{|MD|}{SD_{MD}}$, whereby MD is the mean difference of the respective values of tasty vs. disgusting imaginations and SD_{MD} its standard deviation. The effect sizes were interpreted as small (0.2), moderate (0.5), large (0.80) or very large (1.3) [35, 36].

For interpreting the reliability of slopes between tasty and disgusting imaginations, the two-way mixed Intraclass correlation coefficient (ICC(3,1)) with absolute agreement was evaluated additionally. The prerequisite of variance homogeneity was checked and fulfilled.

For all comparisons the significance level was set at α = 0.05.

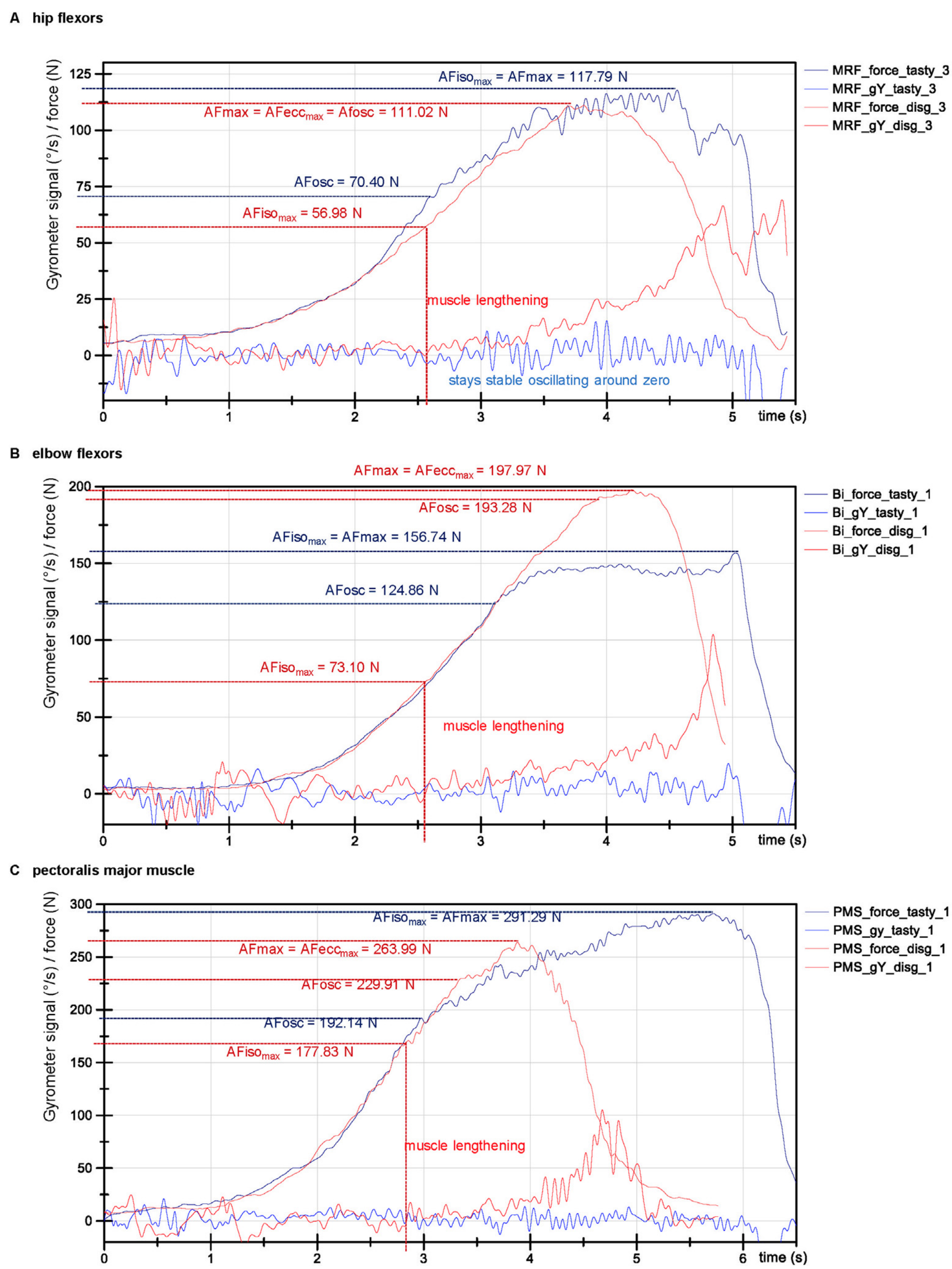

Figure 3. Exemplary signals during manual muscle tests. Displayed are the force (N) and gyrometer (°/s) signals recorded during MMTs while imagining disgusting (red) or tasty (blue) foods, respectively. Each panel corresponds to the MMT of the same muscle of one participant tested by the same tester (A: hip flexors, B: elbow flexors, C: PMS). The values of AFmax, $AFiso_{max}$, $AFecc_{max}$ and AFosc (all in N) are given.

3. Results

3.1. Assessment of the manual muscle test by the tester

During disgusting imaginations all 30 trials were assessed as "unstable" by the testers, whereas all 30 trials during tasty imaginations were assessed as "stable". This applies also for the special case. However, in this case the as "unstable" assessed trials were felt as extremely weak and the muscle lengthening started at an extremely low force level – this was preceived by the tester manually and was supported by the objective measurements (see below).

3.2. Examples for MMT profiles during tasty vs. disgusting imaginations

Figure 3 depicts examples of force and gyrometer signals of the MMTs of the hip and elbow flexors as well as of the sternal part of the pectoralis major muscle (PMS) comparing disgusting and tasty imaginations of the same participants. In all cases, this refers to "unstable" and "stable" assessed MMTs, respectively. The high reliability of the testers' force profiles applications are indicated by the almost identical force rises of the trials during disgusting or tasty imaginations (Figure 3). Additionally, during tasty imaginations, the gyrometer signals stayed quasi-stable oscillating around zero until the AFmax was reached under quasi-static conditions. In contrast, during disgusting imaginations, the gyrometer signals deviated from zero at a comparable lower force level. Those breaking points (first moment at which the gyrometer signal leaves the zero line consistently) are marked in the Figure, since it is not clearly visible due to the given resolution. For the examples depicted in Figure 3, the $AFiso_{max}$ during disgusting imaginations occurred at a substantially low force level of ~51%, 25% and 67% of the respective AFmax for hip flexors, elbow flexors and pectoralis major muscle, respectively. During tasty imaginations, the values of AFmax correspond to $AFiso_{max}$ in all three cases. The decisive difference is that during disgusting imaginations the participants started to lengthen their muscles at a substantially lower force level ($AFiso_{max}$), whereas during tasty imagination a muscle lengthening did not appear. Furthermore, the onset of oscillations occurred at a considerably lower force level during tasty imaginations compared to disgusting imaginations. The relation of $AFosc_{tasty}$ to $AFosc_{disg}$ amounts to 64%, 65% and 84% for hip flexors, elbow flexors and pectoralis major muscle, respectively.

Those curve shapes illustrate the basic behavior of AF during the different food imaginations which regularly appeared in all measurements except for one participant, which is considered as special case. All other cases were included in the following statistical group comparisons.

3.3. Slope of force profiles

The slopes did not show a significant difference between disgusting and tasty imaginations ($p = 0.430$) with a low effect size of $d_z = 0.261$ (Figures 3, 4, Table 2). The ICC(3,1) = 0.929 ($p < 0.001$), which speaks for a high agreement between the slopes of tasty and disgusting trials and indicates excellent reliability [37]. Hence, the subsequent considerations of AF parameters are based on the prerequisite of reproducible force profiles regarding the MMTs during different imaginations.

3.4. Maximal Adaptive Force and maximal isometric Adaptive Force

The AFmax showed no significant difference between disgusting and tasty imaginations ($p = 0.438$) (Table 2, Figure 5A). The AFmax during tasty imaginations amounted on average 95 ± 18% of the AFmax during disgusting imaginations. It is necessary to mention that the AFmax during tasty imagination occurred during isometric conditions, whereas by imagining disgusting food, the AFmax was reached during muscle lengthening.

The maximal holding capacity ($AFiso_{max}$) was substantially and significantly lower during disgusting imaginations compared to tasty ones ($p = 0.001$, $d_z = 1.597$) (Table 2, Figure 5B). That indicates the

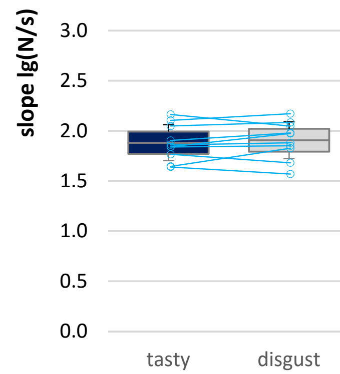

Figure 4. Slope. Displayed are the arithmetic means, standard deviations (error bars) and 95%-CIs of the decadic logarithmus of slope (lg(N/s)) from 70% to 100% of $AFiso_{unst}$ comparing the MMTs during tasty (blue) and digusting (grey) imaginations. The single values are given by light blue points. The t-test revealed no statistically significant difference between tasty and disgusting imagination ($p > 0.05$).

muscle started to lengthen at a considerably lower force level by imagining disgusting compared to tasty food. The participants were not able to adequately resist the external force rise anymore. This was especially visible regarding the ratio $\frac{AFiso_{max}}{AFmax}$ (Table 2, Figure 5C). The participants gave way at averagely 61 ± 19% of the AFmax during disgusting food imaginations and could maintain the position nearly up to 100% during tasty imaginations ($p < 0.001$, $d_z = 2.241$). This indicates, firstly, the maximal holding capacity is immediately reduced by imagining disgusting food. Secondly, the maximal holding capacity is similar to the maximal Adaptive Force during tasty imaginations. Thirdly, the $AFiso_{max}$ seems to be very variable especially during the as unstable assessed MMTs (disgust), which is shown by the coefficient of variation (CV) of the three trials per participant. The CV amounted on average 27.0 ± 17.6% for disgusting and 6.2 ± 4.8% for tasty imaginations.

3.5. Adaptive Force at the onset of oscillations

The stable MMTs were characterized by an early onset of oscillations in the force signal (Figure 3). The onset of oscillations arose at a significantly lower force level of 125.4 ± 46.8 N during tasty imaginations compared to 175.7 ± 34.2 N during disgusting imaginations ($p = 0.001$, $d_z = 1.617$) (Table 2, Figure 6A). The ratios $\frac{AFosc}{AFmax}$ and $\frac{AFosc}{maxAFmax}$ clearly illustrate this difference (Table 2, Figure 6B, C) with significant results between tasty and disgusting imaginations ($p = 0.002$, $d_z = 1.390$ and $p = 0.001$, $d_z = 1.488$, respectively). The difference is also depicted by the ratio $\frac{AFosc}{AFiso_{max}}$, which amounted to 67.8 ± 14.3% for tasty and 174.9 ± 70.5% for disgusting imaginations (Figure 6D). That shows during stable MMTs (tasty) the onset of oscillations started clearly before the $AFiso_{max}$. Whereby during unstable MMTs (disgusting), they arose – if at all – after the breaking point on a significantly and around 75% higher force level during eccentric muscle action ($p = 0.001$, $d_z = 1.582$).

3.6. Behavior of Adaptive Force in a special case

As mentioned above, the hip and elbow flexors of one participant (female, 33 yrs, 58 kg, 168 cm; assessed by tester 2) deviated from the usually occurring AF behavior (Figure 7). The main difference compared to the other participants was the extremely low AFmax during disgusting imagination. Averaged over the three and five trials of the hip flexors and elbow flexors, respectively, the AFmax during disgusting imagination amounted only 35% and 33%, respectively, of the AFmax during tasty imagination. Regarding the parameter $AFiso_{max}$, the ratios between disgusting and tasty imaginations amounted 27% and 11% for hip and

Table 2. Displayed are the arithmetic means (M), standard deviations (SD), lower and upper border of 95%-CIs as well as the p-values and effect sizes d_z of all parameters for tasty vs. disgusting imaginations.

Parameter	imagination	M ± SD	CI (lower; upper)	t	df	Sign. p	d_z
AFmax (N)	tasty	187.58 ± 64.22	147.77; 227.38	−0.811	9	0.438	0.257
	disgust	196.33 ± 49.37	165.73; 226.93				
$AFiso_{max}$ (N)	tasty	185.69 ± 64.10	145.87; 225.33	5.049	9	**0.001**	**1.597**
	disgust	119.49 ± 53.26	86.48; 152.50				
Ratio $AFiso_{max}$ to AFmax (%)	tasty	99.06 ± 2.97	97.22; 100.90	7.088	9	**<0.001**	**2.241**
	disgust	60.62 ± 19.02	48.83; 72.41				
Ratio $AFiso_{max}$ to maxAFmax (%)	tasty	82.36 ± 13.82	73.80; 90.93	5.580	9	**<0.001**	**1.765**
	disgust	54.26 ± 17.49	43.42; 65.10				
AFosc (N)	tasty	125.36 ± 46.82	96.34; 154.37	−5.113	9	**0.001**	**1.617**
	disgust	175.74 ± 34.15	154.57; 196.90				
Ratio AFosc to $AFiso_{max}$ (%)	tasty	67.80 ± 14.32	58.92; 76.68	−5.003	9	**0.001**	**1.582**
	disgust	174.93 ± 70.53	131.21; 218.64				
Ratio AFosc to AFmax (%)	tasty	67.36 ± 14.67	58.27; 76.45	−4.936	9	**0.002**	**1.390**
	disgust	91.33 ± 10.77	84.66; 98.00				
Ratio AFosc to maxAFmax (%)	tasty	55.56 ± 14.18	46.78; 64.35	−4.705	9	**0.001**	**1.488**
	disgust	82.01 ± 10.41	75.56; 88.46				
Slope lg(N/s)	tasty	1.88 ± 0.18	1.77; 1.99	−0.827	9	0.430	0.261
	disgust	1.91 ± 0.18	1.79; 2.02				

Significant results are given in bold.

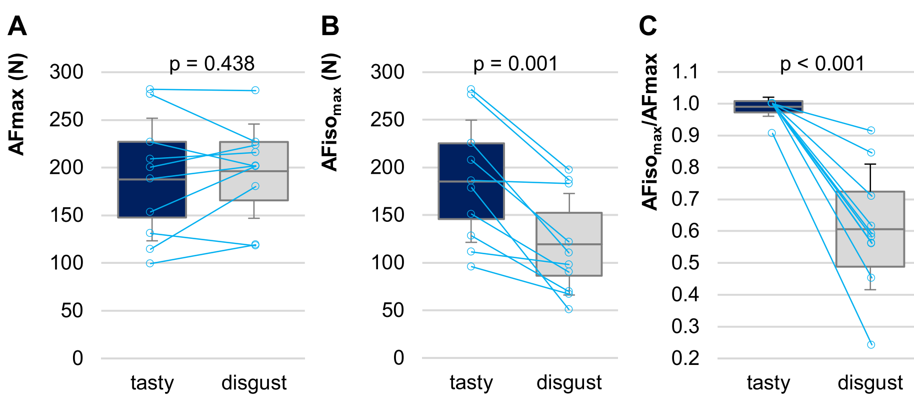

Figure 5. Maximal Adaptive Force and maximal isometric Adaptive Force. Displayed are the arithmetic means, standard deviations (error bars) and 95%-CIs of (A) the maximal Adaptive Force (AFmax), (B) the maximal isometric Adaptive Force (AFisomax) and (C) the ratio of $AFiso_{max}$ to AFmax comparing the measurements with tasty (blue) and disgusting (grey) imaginations. The single values of each participant are illustrated in light blue. The p-values of t-test are given.

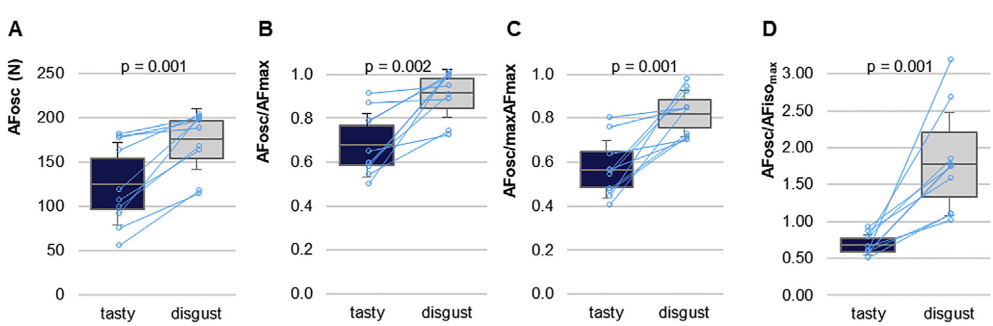

Figure 6. Adaptive Force at the onset of oscillations. Arithmetic means, standard deviations (error bars) and 95%-CIs of (A) the AF at the onset of oscillations (AFosc), (B) the ratio of AFosc to the maximal Adaptive Force (AFmax), (C) the ratio of AFosc to maxAFmax and (D) the ratio of AFosc to $AFiso_{max}$ comparing the measurements with tasty (blue) and disgusting (grey)imaginations are displayed. The single values of each participant are illustrated in light blue. The p-values of t-test are given.

elbow flexors, respectively. For all trials of the other participants (Figure 3, Table 2), the AFmax during disgusting imaginations was on a similar high force level compared to tasty imaginations. In the special case, the ratio $\frac{AFiso_{max}}{AFmax}$ during disgusting imagination amounted 77 ± 13% and 41 ± 6% for hip and elbow flexors, respectively. This is similar to the other participants, even though the AFmax during disgusting food is extremely low for the special case. Another main difference was the onset of oscillations on a low force level ($\frac{AFosc}{AFmax} = 77 \pm 20\%$) for the elbow

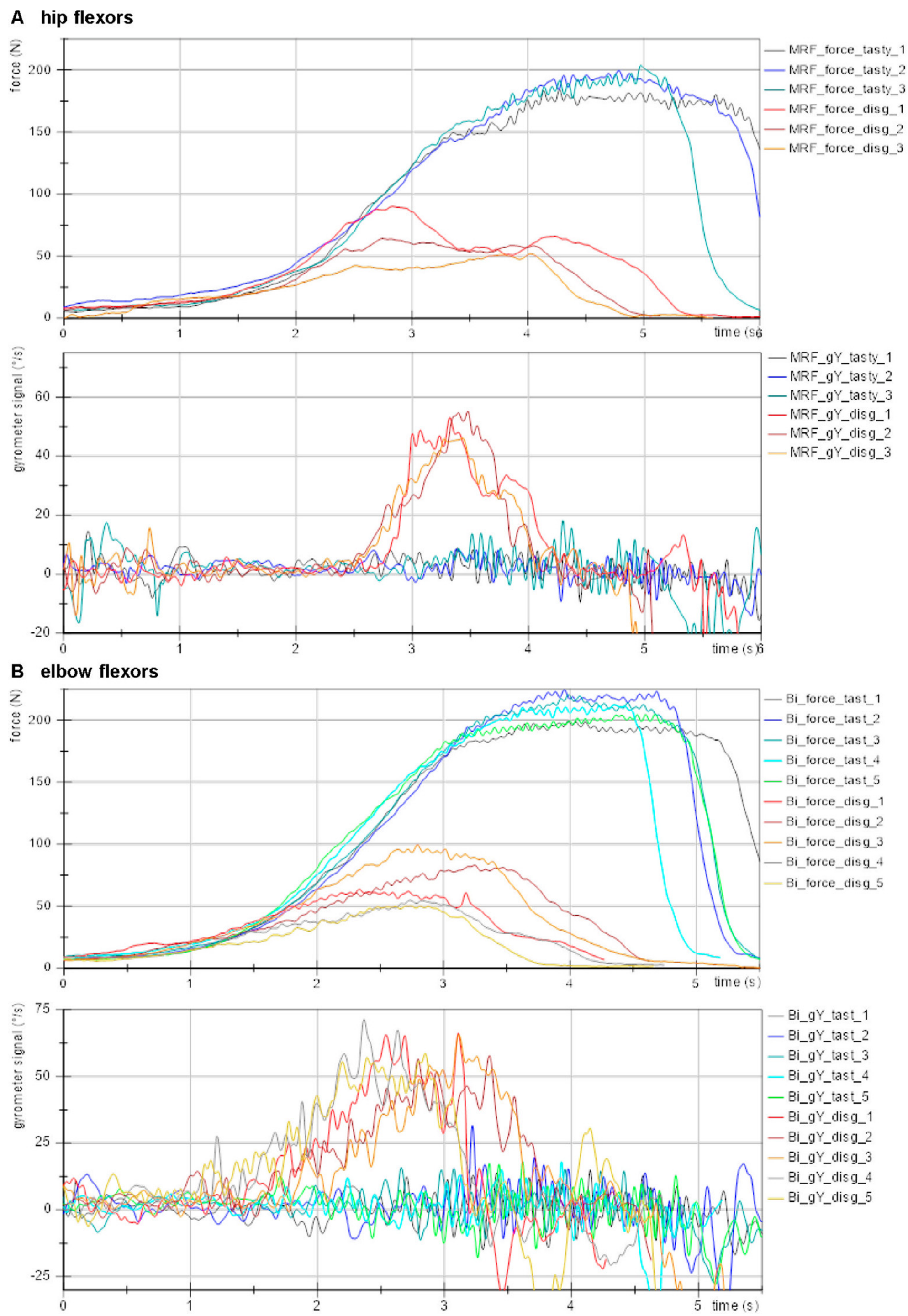

Figure 7. Recordings of manual muscle tests of the special case. Displayed are the force (N) (above) and gyrometer (°/s) (below) signals recorded during the MMTs during disgusting (red/yellow) and tasty (blue/green) food imaginations. A: hip flexors (3 x tasty, 3 x disgusting). B: elbow flexors (5 x tasty, 5 x disgusting).

extensors also during disgusting food imaginations. This is in contrast to the other participants who showed comparable ratios for tasty imaginations, not for disgusting ones. However, a similarity between the special and the other cases was that the oscillations during disgusting imaginations arose during eccentric muscle action. Under tasty imaginations, they occurred during isometric muscle action. Primarily, it was not expected that the AFmax would be that low. Since both muscles of the participant showed that behavior, it is assumed that it reflects a generalized but specific state of regulation.

4. Discussion

The present study examined the dynamics and kinematics during the manually assessed AF using a handheld device in healthy participants under the influence of tasty or disgusting food imaginations. The non-significance and high ICC(3,1) of slopes between both imaginations as well as the low CV of 6.2% of the AFmax during stable MMTs indicate the subsequent discussion is based on reliably applied force rises of the testers. The main outcomes were:

(1) As hypothesized, the maximal AF (AFmax) did not differed significantly between tasty and disgusting imaginations. The difference is that the AFmax was achieved under isometric conditions for tasty imaginations, but during muscle lengthening for disgusting imaginations. An exception was the special case, for which also the AFmax decreased significantly during disgusting imagination. However, also including the special case, the statistical result would not have changed.
(2) The $AFiso_{max}$ showed a significantly lower level by imagining disgusting compared to tasty food with a very large effect size of $d_z = 1.597$, which confirmed the hypothesis. The participants passed into eccentric muscle action at a significantly lower force level (~61% of $AFecc_{max}$) during disgusting imaginations. In contrast, during tasty imagination the isometric position was maintained almost up to the AFmax (~99%).
(3) The AF at the onset of oscillations (AFosc) was significantly lower for tasty compared to disgusting imaginations with a very large effect size of $d_z = 1.617$. Therefore, it is suggested the AF in healthy persons under stable conditions (tasty) is characterized by oscillations, which arise during the force increase still under isometric conditions at ~ 68% of the AFmax. During unstable conditions (disgust), the AF showed no or only poor oscillations which emerge at a high force level of ~91% of the AFmax. Here again, the special case is an exception.

The force profile is a result of the interaction of the tester and the participant. The AFmax does not necessarily reflect the maximal strength of the participant, since the amount to which the participant's holding capacity is challenged depends also on the tester. Nevertheless, the AFmax under unstable conditions refers to the participant's maximal eccentric force under the present circumstances. That is why we also considered the total maximum of all trials. This will be the closest to the maximal strength of the participant. The $AFiso_{max}$ during unstable conditions definitely corresponds to the participant's maximal holding capacity under the apparently impairing influence of a disgusting imagination. In those cases, a yielding of the limb occurred followed by a further force rise up to the $AFecc_{max}$ (= AFmax). Only for the special case, the $AFecc_{max}$ was also extremely low during unstable MMTs (discussion see below). The $AFiso_{max}$ was strongly varying intra- and interpersonally. For example, in Figure 3 it was visible that the elbow flexor passed into eccentric muscle action at a very low force level (~25% of AFmax). The other trials of that participant showed a higher $AFiso_{max}$ (37% and 74% of the AFmax). We assume that this is due to a strong regulation of the participant at this moment rather than due the muscle type. This is underpinned by another participant who showed an averaged $AFiso_{max}$ of the hip flexors of 24 ± 4% of the AFmax. Hence, it is assumed the $AFiso_{max}$ reflects the actual regulation status of the participants (see below).

Since the MMT is generally performed in submaximal areas in the present study, nothing can be stated about the amount of $AFecc_{max}$ during tasty food imagination. Investigations remain.

4.1. Neurophysiological explanation of muscular adaptations regarding emotionally related imaginations

To support the understanding of the underlying mechanisms of AF, the supposed neuromuscular processing must be taken into account. This was done in detail in Schaefer et al. (2021) [10] and should only be briefly described here. During the manually assessed AF, the tester applies a force by contacting the participant's limb, which leads to a sensory mechanical input perceived by skin and joint receptors, muscle spindle cells and Golgi tendon organs. The sensory signals are forwarded to spinal and supraspinal structures providing the status of the current muscle tension, length and joint position [38, 39, 40]. Based on the literature, at least the thalamus, cerebellum, ION, red nucleus, basal ganglia, cingulate cortex and the sensorimotor cortex are participating in the complex processing of adaptive motor control and are connected directly or indirectly [14, 15, 16, 17, 18, 19, 20, 21, 22, 26,38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68]. It was assumed that a combined mechanism of feedback and feedforward control is involved in the adaptive process [20]. We suggest this is also applicable for the AF. Reafferences are contrasted with a copy of the initial motor command [41], and possible mismatches are fixed by adjustments regarding the muscular output. The role of the olivocerebellar circuitry was described in the introduction. Furthermore, the thalamus is considered as a central switching point for sensory and motor processes [55]. Additionally, the cingulate cortex participates in processing emotions as well as pain and is involved in motor control [26, 42, 48, 58]. The high interconnections of this area to other central structures and the reaction to various sensory inputs as proprioception, nociception and exteroception are secured [26, 48]. The basal ganglia are considered as a sort of filter station for the muscle tone by inhibiting undesired and facilitating desirable motor programs [17, 18, 42]. Finally, the motor cortex collects information of the thalamus, the cerebellum, the basal ganglia, the limbic system and the red nucleus [45, 49]. It is suggested that all those networked central structures are required and relevant for controlling muscle tension and length while adapting to external forces.

There are also neuronal correspondences with the mechanical muscular oscillations of around 10 Hz occuring in stable MMTs. They can be found in the neurons of central stuructures, e.g., in the cerebellum (~8–17 Hz) [43], the olivocerebellar circuitry (10 Hz) [43, 64], the thalamus and the motor cortex (11–30 Hz [55]; ~10 Hz [69, 70, 71]). Moreover, proprioceptions are processed with ~10 Hz regarding the long latency reflex [59, 65] and corrections with regard to a changing external force show latencies of ~100ms [39, 68]. Therefore, it is hypothesized that those oscillations are necessary and reflect a normal functioning of the complex neuromuscular network. In this regard, their absence might be indicating irritations of the neuromuscular processing, implied by the absence of oscillations during unstable MMTs here.

The findings of the present and the previous performed study concerning olfactory inputs [10] indicate that the neuromuscular adaptation of healthy participants can be impaired immediately by negative inputs like unpleasant imaginations or olfactions (disgust). It is assumed that the imagination tasks of the present study activated linked emotions. Therefore, we presume the tasty food imagination led to positive and the disgusting one to negative emotions. Under this assumption it is concluded, the obtained findings of a reduced maximal adaptive holding capacity and the later or missing onset of oscillations are a result of the input of negative emotions. As was mentioned, each emotion has expressions on the level of autonomic, endocrine and motor systems [58]. Several investigations pointed out the link and even influence of emotions on the functioning of central structures and motor control. For example, the cerebellum, the basal ganglia and the cingulate cortex include functions for both, emotional processing and motor control [18, 26, 45, 51, 58, 72]. Investigations showed, that the posterior part of the cerebellum is activated by emotions like fear, anger, disgust, sadness and happiness [73, 74]. This supports findings that the regulation of positive and negative emotions are based on shared as well as on different neurocognitive mechanisms [27, 75, 76, 77]. Negative emotions (compared to positive) seem to elevate the activity of, e.g., the prefrontal cortex [77, 78], the parietal cortex, the right insula and the dorsal anterior cingulate cortex [77]. In turn, positive emotions enhance the activty in the amygdala [76], the subgenual anterior cingulate cortex, hippocampus and occipital areas [77]. With regard to specific emotions, fear activates frontal, parietal and occipital parts of the cortex [25, 79]. The perception of fear affects the motor control by the amygdala which directly or indirectly inhibits the motoric processing in the supplementary motor cortex or the subthalamic nucleus [25]. Moreover, disgust stimulates subcortical and cortical areas as the amygdala and the insular cortex [79]. In general, the brain activity during negative emotions was found to be higher compared to positive emotions [77]. The observed activation of greater cognitive resources during negative emotions might be one explanation for the here found results of the impaired Adaptive Force ($AFiso_{max}$, AFosc). Besides, the involvement of specific brain areas during positive or negative emotions might have led to the results. The above mentioned inhibiting effect of motor control by the amygdala during the perception of emotions like fear might play a key role. However, further investigations on this topic remain.

Looking at the motor output, it was shown that anxiety reduced balance control [80]. Another study showed a significant increase of amplitude and significant decrease of mean frequency in EMG of the trapezius muscle during a stressful situation compared to non-stressful situation [81]. Based on all those statements the linkage of motor control and emotions can be stated as proven. The question remains, how this change in motor output might be identified. The Adaptive Force, especially the maximal isometric AF, might be a suitable approach to quantify the effect of emotions on motor control.

4.2. Characteristics of the isometric Adaptive Force

Based on the present findings, the most relevant force parameter regarding the influence of affecting sensory inputs seems not to be the maximal strength (as often utilized for investigations), but the maximal holding capacity during adaptation to an increasing force ($AFiso_{max}$). In case of disturbing influences, muscles seem to reduce their ability to hold the position despite a further increase of tension during lengthening. The muscle gets unstable although a much higher force capacity is available – indicated by the high AFmax. It has to be pointed out that this effect occurred immediately after exposure to the irritating stimulus and is immediately reversible with switching to a positive imagination. Especially, the $AFiso_{max}$ seems to be sensitive regarding negatively felt imaginations or odors [10]. It is assumed that other interfering inputs as, e.g., nociceptions might lead to a similar reaction. We suggest that in case the maximal holding capacity is impaired, the muscles are not able to stabilize joints appropriately anymore. Complaints or even injuries might be the result if the musculoskeletal system is under strain. This could be an explanation, why also well-trained athletes suffer from injuries without external contact despite their well-trained status. Referring to the present study, that also means that influences as negative emotions might lead to complaints of the musculoskeletal system, which have been discussed for years [82, 83, 84, 85, 86]. For patients with mental illness an increased risk of physical diseases is reported [87]. The causal relationship between, e.g., back pain and negative emotions or depressions are mostly unclear [88, 89]. Investigations examined especially the influence of pain on emotions. However, there are also hints for the reversal relation [86, 89]. Based on the present findings, the muscular adaptive holding function could be impaired by negative emotions. This, in turn, might result in pain due to the missing joint stabilization. Therefore, we hypothesize that negative emotions might lead to pain.

Due to the complex networking of different central structures during muscular adaptation according to the AF, it is likely that other external or internal stimuli passing those control circuitries might influence the Adaptive Force, too. As it was mentioned, different health complaints influence the muscular function [90, 91, 92, 93, 94, 95, 96, 97, 98, 99]. An impairment of the maximal adaptive holding capacity is conceivable thereby.

Finally, adequate adaptation seems to be characterized by an early onset of neuromuscular oscillations. The results indicate that the arising mechanical oscillations of ~ 10 Hz might be a prerequisite for maintaining muscular stability. At least, that phenomenon appears in muscular interaction of two healthy persons [31, 32] and might show changes in orthopedic and neurodegenerative diseases like Achillodynia [100] or Parkinson's disease [101, 102]. Changes of this oscillatory capacity might be a sign of an impaired sensorimotor processing.

Therefore, the parameters of AF including oscillations might be suitable to objectify the status of the neuromuscular regulation and to support the understanding and diagnosis of different health states.

4.3. Characterization of "stable" vs. "unstable" adaptation

In a previous study, a first definition of "stable" and "unstable" adaptation to an increasing external force was already suggested [10]. The study revealed a lack of the holding capacity in the sense of $AFiso_{max}$ under the influence of disturbing olfactory perception but muscular stability by perceiving pleasant odors. A comparable behavior was found in the present study. That indicates that a switching into impaired stability of muscles might be provoked by different disturbing inputs. Taking both studies together, for stable MMTs the ratio $\frac{AFiso_{max}}{AFmax}$ amounted $\sim$99 $\pm$ 3% and the ratio $\frac{AFosc}{AFmax} \approx 73 \pm 12\%$; for unstable MMTs the ratios revealed $\sim$60 $\pm$ 15% and $\sim$93 $\pm$ 9%, respectively. The quantitative data may vary depending on the particular affecting input but their substantial changes strongly suggest a switching towards an altered quality of motor control during adaptive muscle actions.

It is proposed the unstable behavior reflects an insufficient adaptation of muscle tension and length regarding an external increasing force application. This can be caused by unpleasant imaginations or olfactions (disgust). Thereof it is summarized, that an adequately adapted muscle tension while maintaining muscle length accompanied by the appearance of mechanical oscillations characterizes a well-functioning unimpaired neuromuscular adaptation to an external force rise.

4.4. Special case as example for a possible intense regulation

In one participant not only the $AFiso_{max}$ decreased during disgusting imaginations, but also the AFmax. Both tested muscles of this special case showed an extremely low AFmax during unstable MMTs, which amounted only approximately one third of the AFmax under stable conditions. The stable MMTs showed that the muscles can immediately develop a significantly higher force (AFmax = $\sim$200 N (stable) vs. $\sim$70 N (unstable)). This indicates an extremely sensitive reaction towards interfering influences, at least for emotionally related imaginations, which is interpreted as a very strong regulation.

The finding that the oscillations of elbow flexors appeared already on a low force level under unstable conditions was not expected at all. Explanations for this can only be assumed. Probably, the neuromuscular system tries to rescue the strongly impaired motoric adaptation by the onset of oscillations, but clearly is not able to manage it. The oscillatory frequency of the 5 trials was significantly higher during tasty vs. disgusting imaginations (14.8 $\pm$ 1.1 Hz vs. 12.8 $\pm$ 0.8 Hz, $p = 0.022$). Further investigations of the oscillatory characteristics remain.

From experience in therapeutic practice, persons with such strong regulations are known. In case of complaints or other interfering inputs, those persons show an extremely low holding capacity in contrast to persons with a rather "normal" intensity of regulation. Probably, those persons are especially vulnerable to develop complaints of the musculoskeletal system or diseases according to functional weakness. The causal relationship remains open.

4.5. Limitations

The main limitation seems to be the testers' force application. The MMT is rightly critisized to be subjective. However, the force profile is objectified by using the handheld device. This opens up the possibility of a post hoc control. The force application must be approriate and reproducible [8]. The low CV of the $AFiso_{max}$ during stable conditions of $\sim$6.2% speaks for a reproducibly applied maximal force by the tester. This value is similar or even low compared to the CV of isokinetic measurements which is seldomly below 7% (range 3.7–21.7%) [103, 104, 105]. Additionally, since the slopes did not show a significant difference between the MMTs with different imaginations and the ICC(3,1) was very high, we consider the reproducibility of force application as fulfilled. Therefore, the frequent criticism that the reason for an unstable

MMT might be a steeper force increase can be neglected for the present investigation.

Another limitation might be the assessment of different muscles depending on their eligibility (hip and elbow flexors, pectoralis major muscle). All of them showed basically similar behavior, especially the hip and elbow flexors responded nearly identically. The onset of oscillations appeared earlier during the test of the pectoralis major muscle. This might be a result of the longer lever length which could lead to larger excursions during oscillations.

The small sample size is considered as a further limitation ($n = 10$ plus $n = 2$ muscles for the special case). Nevertheless, the p-values and effect sizes are very clear. Further investigations must verify these preliminary findings on the base of a larger sample size.

Eventually, another and crucial limitation could be the non-randomized order of different imaginations and the missing blinding. A double-blinding is impossible, because the participant has to perform the respective imagination. Since the study was explorative, we deliberately omitted both aspects. A follow-up study will include the randomization and the single-blinding. Since the disgusting imaginations were performed at first, fatiguing effects can be excluded as reason for the lower holding capacity. Because the $AFiso_{max}$ was significantly higher in the last three trials (tasty), the results are even more convincing. An involuntary change of the testers' force rise might have been appeared according to tasty or disgusting imaginations due to the missing blinding on the testers' side. An unintentional abrupt start and steeper force rise could have provoked an unstability of the tested muscle. However, this was controlled by considering the slope prior to the breaking point. Furthermore, the oscillations and their onset at a reproducible threshold cannot be imitated by the tester or the participant. Therefore, the results rebut the concern of unconscious manipulations.

Considering those limitations, the results can only be interpreted as preliminary findings to help understanding the influence of emotionally related imaginations on the neuromuscular control of healthy participants.

5. Conclusion

The present investigation was the first on the topic of the influence of emotionally related imaginations on the AF. The findings suggest the maximal adaptive holding capacity ($AFiso_{max}$) might be reduced by negative emotionally related imaginations. Assuming the AF during tasty imaginations reflects "normal" motor function, the AF behavior during disgusting imagination is interpreted as an impaired neuromuscular control due to a disturbing intervention. This resulted in the assumption, the occurrence of mechanical muscular oscillations during isometric holding function might be one or even the crucial indicator characterizing a well-functioning neuromuscular control. As already stated in Schaefer et al. [10], the core might be the adequate processing of muscular length and tension control, which presumably is based on a complex control cascade and parallel working processes between the central areas characterized by oscillations. In a healthy, uneffected neuromuscular system, those complex control processes allow for an adequate adaptation to the external force application. Because of its reversible nature this impaired holding function can be understood as a kind of functional weakness.

The study indicates that measuring the AF might provide insights into regulative motor processes. It could offer an approach to investigate the neuromuscular system regarding interfering influences affecting the control circuits. This might be a key to investigate injury mechanisms or musculoskeletal complaints.

Eventually, regarding the reasonable criticism concerning the MMT to be subjective, a measurement tool like the presented handheld device could support the acceptance of the MMT by measuring the kinematics and dynamics in order to objectively assess the force application. To ensure valid and reliable measurements, the skills of examiners should be investigated in advance [8]. The preliminary character of the presented investigation leads to the necessity of enlarging the data base.

Declarations

Author contribution statement

Laura V. Schaefer: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Silas Dech: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Frank N Bittmann: Conceived and designed the experiments; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data will be made available on request.

Declaartion of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

We acknowledge the International College of Applied Kinesiology (ICAK-US) for its support of our investigations by providing a donation. The development project regarding the handheld device was performed in cooperation with StatConsult (Magdeburg, Germany). Additionally, we would like to thank all participants.

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