Aus dem Fachbereich Medizin
der Johann Wolfgang Goethe Universität
Frankfurt am Main

betreut am
Zentrum der Gesundheitswissenschaften
Institut für Arbeitsmedizin, Sozialmedizin und Umweltmedizin
Direktor: Prof. Dr. Dr. David Groneberg

Effekte eines Dehntrainings auf die Lebensqualität von Büroangestellten im Rahmen der betrieblichen Gesundheitsförderung

Dissertation
zur Erlangung des Doktorgrades der theoretischen Medizin
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vorgelegt von
Fabian Christian Holzgreve

aus Frankfurt am Main

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Abkürzungsverzeichnis

MSE	-	Muskelskeletterkrankungen
BGF	-	betriebliche Gesundheitsförderung
SD	-	Standardabweichung
SF-36	-	Short-Form-36
KI	-	Konfidenzintervall
KÖFU	-	Körperliche Funktionsfähigkeit
KÖRO	-	Körperliche Rollenfunktion
SCHM	-	Schmerz
AGES	-	Allgemeine Gesundheitswahrnehmung
VITA	-	Vitalität
SOFU	-	Soziale Funktionsfähigkeit
EMRO	-	Emotionale Rollenfunktion
PSYC	-	Psychische Gesundheit
KSK	-	Körperliche Summenskala
PSK	-	Psychische Summenskala
TFL	-	Tiefe Frontale Armlinie
OFL	-	Oberflächliche Frontale Armlinie
IG	-	Interventionsgruppe
KG	-	Kontrollgruppe

Index of abbreviations

MSD	-	musculoskeletal disorders
SD	-	standard deviation
SF-36	-	Short-Form-36

1 Zusammenfassung

1.1 Deutsch

Muskelskeletterkrankungen (MSE) sind die Hauptursache für Arbeitsunfähigkeit bei Büroangestellten in Deutschland. Die Produktionsausfallkosten für MSE beliefen sich im Jahre 2017 auf 17,2 Milliarden Euro. Neben haltungsbezogenen Risikofaktoren wie die statische Körperhaltung am Büroarbeitsplatz, konnten zunehmend psychische Stressoren wie Termin- und Leistungsdruck als Risikofaktoren identifiziert werden. Arbeitgeber versuchen mittels verhaltens- und verhältnispräventiven Maßnahmen im Rahmen der (BGF) am Arbeitsplatz zur Prävention beizutragen. Insbesondere Bewegungsprogramme führen nachweislich zu einer Verringerung von MSE und Stress sowie zu einer Verbesserung der Lebensqualität. Vielversprechend sind untere andrem auch Dehninterventionen wie die wenigen bislang veröffentlichten Studien zeigen. Das „five-Business“ Dehnprogramm, dass an einem Gerät durchgeführt wird, wurde speziell für die Anwendung im Büro konzipiert und beinhaltet fünf einfache Übungen für den Rumpf. Ziel dieser Studie war es daher, die Auswirkungen des "five-Business" Trainingsprogramms für Büroangestellte auf MSE, die Lebensqualität und die Beweglichkeit zu untersuchen.

Im Rahmen der hier vorgestellten Promotionsarbeit wurde zunächst eine konkrete Methode entwickelt (Publikation 1) und anschließend der Effekt dieses Dehntrainings auf die Lebensqualität untersucht (Publikation 2). Insgesamt nahmen 313 Büroangestellte (173m/137f) mit einem Durchschnittsalter von 43,37 ± 11,24 (SD) Jahren, einer Körpergröße von 175,37 ± 9,35 cm und einem Gewicht von 75,76 ± 15,23 kg sowie einem durchschnittlichen BMI von 24,5 ± 3,81 kg/m^2 freiwillig an dieser Interventionskontrollstudie teil. Die 158 Teilnehmenden der Interventionsgruppe absolvierten das Dehntraining zweimal wöchentlich für etwa zehn Minuten über eine Dauer von 12 Wochen. Die Kontrollgruppe hingegen sollte ihrem gewöhnlichen Alltag weiter nachgehen. Der Short-Form-36 Fragebogen (SF-36) wurde verwendet, um die Effekte der Intervention zu Beginn und nach 12 Wochen auf die gesundheitsbezogene Lebensqualität zu evaluieren. Nach 12 Wochen Dehntraining traten signifikante Verbesserungen in den Bereichen mentaler Summenscore (p=0,008), körperliche Funktionsfähigkeit (p<0,001), körperliche Schmerzen (p=0,01), Vitalität (p=0,025), Rolleneinschränkungen aufgrund körperlicher Probleme (p=0,018) und psychische Gesundheit (p=0,012) auf. Die Ergebnisse zeigen, dass das Dehntraining nicht nur physische Gesundheitsparameter beeinflusst, sondern ebenfalls positive Effekte bei psychischen Gesundheitsparametern hervorruft. Das Dehntraining ermöglicht demnach sowohl auf physischer als auch auf psychischer Ebene eine Entspannung. Daher deuten die Ergebnisse

insgesamt darauf hin, dass ein 12-wöchiges Dehnprogramm geeignet ist, die gesundheitsbezogene Lebensqualität von Büroangestellten zu verbessern. Es kann geschlussfolgert werden, dass ein solches Dehnprogramm als präventive und rehabilitative Maßnahme in der betrieblichen Gesundheitsförderung geeignet sein kann, um aktuelle Herausforderungen des zunehmenden Wettbewerbs und steigenden Produktivitätsanforderungen am Arbeitsplatz entgegenzuwirken.

1.2 Englisch

Musculoskeletal disorders (MSD) are the main cause of incapacity to work among office workers in Germany. In 2017, the production downtime costs for MSD amounted 17.2 billion euros. In addition to posture-related risk factors such as static posture at the office workplace, psychological stressors such as pressure to meet deadlines or performance pressure have been identified as risk factors. Employers are attempting to counteract these by means of behavioral and situational preventive measures within the framework of workplace health promotion. Exercise programs in particular have been shown to reduce MSD and stress and to improve the quality of life. To date, hardly any stretching interventions have been evaluated, although the few studies published to date have produced promising results. The "five-Business" stretching program was specifically designed for the application in the office and includes five simple exercises on a device for the trunk. The aim of this study was therefore to investigate the effects of the "five-Business" training program for office workers on MSD, quality of life and mobility. The effect of this stretching training on the quality of life was examined in the context of the doctoral thesis presented here. A total of 313 office workers (173m/137f) with an average age of 43.37 ± 11.24 (SD) years, a height of 175.37 ± 9.35 cm, a weight of 75.76 ± 15.23 kg and an average BMI of 24.5 ± 3.81 kg/m^2 participated voluntarily in this intervention-control study. The 158 participants in the intervention group completed stretching training twice a week for about ten minutes over a period of 12 weeks. The control group, on the other hand, was to continue their normal daily routine. The Short-Form-36 questionnaire (SF-36) was used to evaluate the effects of the intervention at baseline and after 12 weeks on the health-related quality of life. After 12 weeks of stretching, there was a significant improvement in mental sum score ($p=0.008$), physical functioning ($p<0.001$), bodily pain ($p=0.01$), vitality ($p=0.025$), role limitations due to physical problems ($p=0.018$) and mental health ($p=0.012$). The results suggest that a 12-week stretching program for office workers is likely to significantly improve the health-related quality of life. Furthermore, it was shown that stretching not only influences physical health parameters but also has positive effects on mental health parameters. Stretching

training therefore also allows relaxation on a psychological level. It can be concluded that such a stretching program can be suitable as a preventive and rehabilitative measure in workplace health promotion in order to counteract current challenges of increasing competition and rising productivity requirements at the workplace.

2 Übergreifende Zusammenfassung

2.1 Einleitung

In Deutschland sind Muskelskeletterkrankungen (MSE) die Hauptursache für Arbeitsunfähigkeitstage [1-3]. Von 2011 bis 2017 hatten MSE-bezogene Diagnosen einen Anteil von durchschnittlich 22% an allen Diagnosen [1,3]. Hauptsächlich handelte es sich dabei um Rückenschmerzen [2,3]. Der durch MSE verursachte Ausfall an Bruttowertschöpfung lag im Jahr 2016 in Deutschland bei 30,4 Mrd. Euro, dies entspricht 1% des Bruttonationaleinkommens. Eine Arbeitsunfähigkeit auf Grund von MSE dauerte im Schnitt 19,5 Tage [2], wovon Männer durchschnittlich häufiger betroffen waren als Frauen [2,3]. Insgesamt leiden ca. 50% unter mittelstarken Schmerzen und ca. 30% unter starken Schmerzen im Rücken- und Nackenbereich [4,5]. Insbesondere bei Rückenschmerzen ist eine Kombination aus physikalischen und psychosozialen Faktoren maßgeblich für die Entstehung von Rückenschmerzen [6]. In Industrienationen ist der Dienstleistungssektor der dominierende Wirtschaftsbereich [7,8]. Der Hauptanteil der Arbeitszeit wird bei den dort beschäftigten Arbeitnehmenden in statischer Sitzhaltung verbracht [9]. Dadurch können unphysiologische Muskelspannungen entstehen, die MSE begünstigen [10]. Arbeitgeber versuchen mit verhaltens- und verhältnispräventiven Maßnahmen im Rahmen der betrieblichen Gesundheitsförderung (BGF) am Arbeitsplatz zur Prävention beizutragen [11,12].

Zur Reduktion muskuloskelettaler Beschwerden, haben sich berufsspezifische, systematisch angeleitete Dehntrainings als erfolgsversprechender Ansatz erwiesen [13-17]. Beispielsweise konnten Tunwattanapong et al. [13] eine Verminderung von Nacken- und Schulterbeschwerden (-1.4; 95% Konfidenzintervall (KI): -2.2, -0.7 auf der Visuellen Analogskala) und eine Verbesserung der gesundheitsbezogenen Lebensqualität (14.0; 95% KI: 7.1, 20.9 SF-36) belegen. Einen globaleren Ansatz mit nur fünf einfachen Übungen stellt das „five-Business“ Dehntraining (FIVE-Konzept, Hüfingen, Germany) am Gerät dar. Dieses Training wurde auf Basis vom Elementen des Yogas und den Grundlagen von McKenzie unter Berücksichtigung der myofaszialen Leitbahnen nach Myers konzipiert. Insgesamt handelt es sich um ein stark rumpforientiertes, standardisiertes statisches Dehnprogramm am Gerät. Dieses ist schnell und leicht und an einem einzigen Gerät (TÜV geprüft) durchzuführen. Aufgrund der vorgegebenen Übungsdurchführung am Gerät und der individuellen Einstellungsmöglichkeiten der Dehnposition (an Körpergröße und Beweglichkeit) durch das Widerlager sind alle Übungen individualisiert und standardisiert zu gleich. So ist es auch für heterogene Gruppen einsetzbar. Im Gegensatz zu bisherigen Dehninterventionen [13-17] als BGF Maßnahmen ist das Trainingsprogramm rein rumpforientiert und daher attraktiv im Rahmen der Prävention und

Reduzierung von MSE. Darüber hinaus wurden in ähnlichen Dehnprogrammen [13-17] vorwiegend Muskeln isoliert gedehnt, während durch die ergonomisch ungünstige, vornüber geneigte Sitzhaltung eine relative Verkürzung der gesamten vorderen Muskelketten auftreten kann. Durch Übungen, die vorwiegend in die Rumpfextension dehnen (bei „five-Business“: Stand, Chest, Hip), wird versucht muskulären Dysbalancen, die MSE zur Folge haben können, im Rahmen eines mehrkettigen Dehnens entgegenzuwirken. Ähnliche Konzepte wurden bereits im Rahmen der Therapie nach McKenzie [18,19] und auch im Yoga [20,21] erfolgreich angewendet.

Zusammenfassend lässt sich festhalten, dass in diesem ganzheitlich entwickelten Dehnprogramm ganze Muskelketten involviert sind und nicht nur isolierte Muskelpartien separat gedehnt werden wie es bisher in vielen Untersuchungen [13-17] umgesetzt wurde. Dieses Konzept wurde zunächst für den Freizeitsportbereich entwickelt und dient in Fitness-Studios dazu über fünf verschiedene Übungen den Körper in unterschiedliche Extensionspositionen zu bringen. Es soll nun im Rahmen der BGF dazu eingesetzt werden, die Muskelketten (insbesondere im Rumpf- und Hüftbereich), die über mehrere Stunden täglich in einer flektierten Position durch langes Sitzen in einer starren, ungünstigen Weise, verharren, im Ganzen zu dehnen.

2.2 Methode

2.2.1 Erste Publikation: Methodenansatz

2.2.1.1 Probanden

Im Rahmen der Interventions-Kontroll-Studie sollen insgesamt 350 Probanden im Alter zwischen 18 und 65 Jahren vermessen werden. Geplant ist eine nicht-probabilistische Einteilung in eine Interventionsgruppe (n = 250) und eine Kontrollgruppe (n = 100). Ausschlusskriterien sind Probanden mit relevanten Operationen oder operativen Versteifungen am Bewegungsapparat, relevantem künstlichen Gelenkersatz, schweren Erkrankungen, wie z. B. Morbus Bechterew, Chronisch destruierender Gelenkerkrankungen, Multipler Sklerose, myodystropher oder neurodegenerativer Erkrankungen, angeborenen Fehlstellungen des Bewegungsapparates oder akutem Bandscheibenvorfall. Darüber hinaus gelten aktuelle Therapiemaßnahmen im Bereich des Bewegungsapparates, wie aktuelle physiotherapeutische oder orthopädische Therapien, die Einnahme von Muskelrelaxantien oder anderer Medikamente, die Einfluss auf die Dehnfähigkeit der Muskulatur haben, und Schwangerschaft als Kontraindikatoren. Alle Probanden erteilten eine schriftliche Genehmigung zur Teilnahme an dieser Studie. Die Studie wurde von der Ethikkommission der Medizinischen Fakultät der Landesärztekammer Baden-Württemberg genehmigt (F-2017-073).

2.2.1.2 Rekrutierung

Über das interne Gesundheitsmanagement erhalten alle schreibtischgebundenen Mitarbeiter eines Bürogebäudes eines Automobilherstellers via Email das Angebot auf freiwilliger Basis an der Studie teilzunehmen. Die Anmeldung erfolgt über einen Link, der sich ebenfalls in der Nachricht befindet. Anschließend werden alle potentiellen Teilnehmer telefonisch kontaktiert, um die Ausschlusskriterien abzuklären, und auf Basis der Verfügbarkeit die Trainingstermine zu vereinbaren.

2.2.1.3 Messsysteme

<u>Nordischer Fragebogen</u>

Der Nordische Fragebogen erfasst Beschwerden am Bewegungsapparat und wurde von Kuorinka et al. im Jahre 1987 entwickelt [22]. Er ist validiert und international in unterschiedlichsten Berufsgruppen wie z. B. in administrativen Berufen [23-26], bei Fabrikarbeitern [27-30] oder Gesundheitsberufen [31-34] eingesetzt. Grundsätzlich erfragt er allgemeine Angaben, Fragen zur Person, Gewohnheiten, Arbeitssituation, aber gibt auch Übersichten – eingeteilt nach Körperregionen – über die 7-Tages- und 12-Monatsprävalenz sowie die Lebenszeitprävalenz von Beschwerden sowie Funktionsbeeinträchtigungen.

<u>SF-36</u>

Der SF-36 (Version 1.3) wurde 1992 von Ware und Sherbourne in den Vereinigten Staaten [35] entwickelt und enthält Fragen zur allgemeinen Gesundheit und der gesundheitsbezogenen Lebensqualität unter Berücksichtigung physischer, psychologischer und sozialer Faktoren. Er wird verwendet, um den Gesundheitszustand des einzelnen Patienten zu bewerten, die Kostenwirksamkeit einer Behandlung zu erforschen oder, um die Krankheitslast zu überwachen und zu vergleichen [36]. Mit 35 Items erfasst der SF-36 acht Dimensionen der subjektiven Gesundheit: Körperliche Funktionsfähigkeit (KÖFU), Körperliche Rollenfunktion (KÖRO), Schmerz (SCHM), Allgemeine Gesundheitswahrnehmung (AGES), Vitalität (VITA), Soziale Funktionsfähigkeit (SOFU), Emotionale Rollenfunktion (EMRO) und Psychische Gesundheit (PSYC). Die acht Subskalen lassen sich in zwei grundlegenden Dimensionen der subjektiven Gesundheit zuordnen: die körperliche und psychische Gesundheit (KSK und PSK). Je niedriger die Punktzahl, desto stärker die Einschränkung [36] des Probanden. Die Reliabilität der deutschen Version des SF-36 variiert über die einzelnen Subskalen zwischen r=0,67 und r=0,85. In einer Studie mit Rückenschmerzpatienten (n=243) wurden die internen Konsistenzen für alle

Subskalen ermittelt (Cronbach's α 0.60 - 0.93) [36]. Zusätzlich wurden im Rahmen der Erhebung 38 dichotome Fragen zur gesundheitsbezogenen Lebensqualität durchgeführt.

Sportmotorische Tests

Um die Effektivität der einzelnen Übungen hinsichtlich Veränderungen der belasteten aktiven und passiven Strukturen zu evaluieren, werden sportmotorische Tests verwendet. Die Auswahl der Tests erfolgte kongruent zu den gedehnten Muskelketten der einzelnen Übungen. Für die Erfassung des Beweglichkeitsausmaßes werden zwei unterschiedliche Messverfahren verwendet: ein Maßband (Übungen 3 & 5) [37-43] und ein digitales Inklinometer (Übung 1, 2 & 4) [44-54].

2.2.1.4 Studienprotokoll

Das Interventionsprogramm „five-Business“ ist für die Umsetzung im Unternehmenssetting und für Gesundheitsförderung vom kommerziellen Anbieter „FIVE-Konzept“ (Hüfingen/Germany) konzipiert worden. Dabei werden alle Übungen an einem Gerät stehend, mit Schuhen (ausgenommen Absatzschuhe > 5cm) und in „Arbeitskleidung“ durchgeführt. Die Maße des Geräts betragen 116 cm x 82 cm x 128 cm, das Gewicht 60 kg.
Die Probanden führen die folgenden 5 Übungen durch: (1) Stand, (2) Chest, (3) Ischio, (4) Hip und (5) Lateral.

1. Stand: In der Übung „Stand“ werden Knie, Hüfte, Lendenwirbelsäule und Brustwirbelsäule extendiert. Die Halswirbelsäule wird dagegen flektiert. In Anlehnung an die myofaszialen Meridiane nach Myers [55] werden Strukturen der oberflächlichen Frontallinie ((M. sternalis), Fascia sternochondralis, M. rectus abdominis, M. quatrizeps femoris insb. M. rectus femoris, Patellasehne) statisch passiv gedehnt. Der Vollständigkeit halber wird nachfolgend eine Auswahl an Strukturen der Tiefen Frontallinie aufgeführt, die aufgrund der Bewegungsrichtung potentiell beansprucht werden (Fascia endothoracica, M. transversus thoracis, Perikard, Mediastinum, parietale Pleurea, Diaphragma, Lig. longitudinale anterior, Fascia sacralis, M psoas, M. iliacus, M. pectineus, Trigonum femorale, Septum intermusculare mediale, M. adductor brevis, M. adductor longus). Durch Erhöhung des Drehmoments (beispielsweise durch Anheben der Arme) kann sowohl die Dehnungsspannung als auch die isometrische Kontraktion der gedehnten Muskulatur erhöht werden.

2. Chest: Es wird analog zu Stand eine Rückbeuge durchgeführt. Das Widerlager ist auf Höhe der Schulterblätter positioniert, wodurch insbesondere auf den Brustbereich die Dehnungsspannung gebracht wird. Dabei werden Strukturen der Tiefen Frontalen Armlinie (TFL) [55] (M. pectoralis minor, Fascia clavipectoralis, M. biceps brachii, Anteriore Kante des Radiusperiosts, Muskeln des Daumenballens und Lig. Collaterale carpie radiale), der Oberflächlichen Frontalen Armlinie (OFL)[55] (M. pectoralis major, M. latissimus dorsi, Septum intermusculare brachii mediale, Flexoren und Karpaltunnel), der funktionellen Frontallinie (M. pectoralis major, M. rectus abdominis, M. adductor longus) sowie der oberen OFL und TFL beansprucht. Durch aktives Zurückführen der Arme wird die Dehnungsspannung im Brustbereich erhöht, sodass die Übung hauptsächlich dem aktiven statischen Dehnen zugeordnet werden kann.
3. Ischio: In der Übung „Ischio“ wird die gesamte oberflächlichen Rückenlinie [55] (OFL, Galea aponeurotica, epikraniale Faszie, Fascia sacrolumbale, M. erector spinae, Lig. sacrotuberale, Ischiokruralmuskulatur, M. gastrocnemius, Achillessehne, Fascia plataris, kurze Zehenflexoren) durch Extension in Sprung- und Kniegelenk sowie Flexion in Hüfte und Wirbelsäule statisch gedehnt.
4. Hip: Die Übung „Hip“ ähnelt der Übung „Stand“, sodass grundsätzlich dieselben Strukturen wie bei Stand beansprucht (OFL/TFL) werden. Zusätzlich wird hier ein Bein auf das hintere Polster gelegt, wodurch die Hüftstreckung auf dieser Seite verstärkt wird. Das besondere Merkmal ist die willkürliche isometrische Kontraktion der Agonisten. Dies wird durch starkes Anpressen des aufgelegten Fußes gewährleistet. Der Schwerpunkt der Übung „Hip“ liegt auf der Beanspruchung der hüftbeugenden Muskulatur und den damit verbundenen Strukturen.
5. Lateral: Während der Lateralflexion wird die Laterallinie [55] (M. splenios capitis, M. sternocleidomastoideus, Mm. intercostales internus/externus, Mm. obliquus internus/externus, M. gluteus maximus, M. gluteus medius, M. tensor fascia latae, Tractus iliotibialis, Lig. Capitis fibulae anterius, Mm. Peroneus longus/previs) passiv statisch gedehnt. Durch eine Elevation beider Arme bzw. das Halten von Gewichten über dem Kopf kann das Drehmoment erhöht werden. Dies hat sowohl eine erhöhte Dehnungsspannung als auch eine erhöhte isometrische Kontraktion der gedehnten Muskulatur zur Folge.

Die Interventionsstudie ist für eine Dauer von 12 Wochen angesetzt. In der Woche davor und in der Woche danach werden jeweils die sportmotorischen Tests und die Umfragen (Nordic Questionnaire und SF-36) durchgeführt. Dabei wird aus Gründen der Praktikabilität bewusst auf eine Randomisierung der Messreihenfolge der sportmotorischen Tests verzichtet. Die

Probanden absolvieren zwei Mal pro Woche für ca. 10 Minuten das Dehntraining. Jede Übung wird zwei Mal für 20 Sekunden gehalten. Die Zeit wird mit einer Stoppuhr gestoppt. Das Training wird über die Intervention durchgehend von geschultem Trainerpersonal begleitet und gesteuert. Dabei wird nach Möglichkeit auch auf eine progressive Belastungssteuerung geachtet. Dafür wird das Trainingsgerät im Vorfeld mit Markierungen versehen, sodass die Geräteeinstellung und die Standposition über den Trainingsverlauf registriert werden können.
Damit abschließend tatsächliche Veränderungen auf die Intervention zurückzuführen sind, müssen die Probanden ein Trainingstagebuch führen, um Einflüsse aus privater körperlicher Aktivität zu identifizieren. Da über einen Gesamtzeitraum von 14 Wochen unter anderem Urlaube, Krankheiten und Geschäftsreisen eine ausnahmslos konsequente Trainingsteilnahme sowohl während der Studie als auch im realen Arbeitsalltag von Büroarbeitenden unmöglich machen, werden zwei Kulanztermine angeboten, sodass am Ende des Interventionszeitraums die Probanden 22 – 24 Trainingstermine absolviert haben müssen. Die Kontrollgruppe führt im Abstand von 12 Wochen analog zur Interventionsgruppe sportmotorische Tests und die Umfragen (Nordic Questionnaire und SF-36) durch.
Um möglichst genaue Messergebnisse zu erzielen, sollten die Messungen immer vom selben erfahrenen Untersucher durchgeführt werden [48,56]. Alle Messungen werden drei Mal durchgeführt, woraus für die weitere statistische Analyse der Mittelwert gebildet wird [57].

2.2.1.5 Auswertungsparameter

Als Messeinheiten sind Zentimeter und Grad sowie Summenskalen und Angaben der Fragebögen entsprechend der jeweiligen Fragestellung.

2.2.1.6 Statistische Auswertungsverfahren

Für die statistische Auswertung wird das Statistik-Programm „IBM SPSS Statistics 25“ verwendet. Zunächst werden alle erhobenen Daten mit dem Kolmogoroff-Smirnoff-Lilliefors-Test auf Normalverteilung getestet. Für normalverteilte Daten wird der T-Test für gepaarte Stichproben und für nicht normalverteilte Daten der Wilcoxon-Matched-Pairs-Test angewendet. Da die Ergebnisse des Nordic Questionnaires nominal bzw. ordinal verteilt sind, wird für unabhängige Gruppenvergleiche der Chi-Quadrat-Test angewendet. Im Prä-Post-Vergleich wird der McNemar-Test für gepaarte Stichproben oder der Cochrans-Q-Test für Messwiederholungen durchgeführt. Zum Vergleich der Werte zwischen Interventions- und Kontrollgruppe wird für metrische Werte der unabhängige T-Test (normalverteilt) bzw. der Wilcoxon-Mann-Whitney-U-Test (nicht-normalverteilt, metrisch und ordinal) verwendet. Für die Überprüfung von nominal skalierten Werten wird der Chi-Quadrat-Test angewendet. Weiterhin sollen Zusammenhänge zwischen Beschwerden, Veränderungen der Beweglichkeit und der Lebensqualität getestet werden. Hierzu wird bei normalverteilten Werten die Pearson-Korrelation und bei nicht-normalverteilten Werten die Spearman-Korrelation gebildet. Das Signifikanzniveau liegt bei 5%.

2.2.2 Zweite Publikation: Ein individueller und standardisierter Ansatz zur Verbesserung der Lebensqualität von Büroangestellten

2.2.2.1 Probanden

Insgesamt nahmen 313 Büroangestellte (173m/137w) eines großen Automobilkonzerns freiwillig an dieser Interventionskontrollstudie teil. 19,2% (35m/22w) der Teilnehmer der Interventionsgruppe mussten die Studie vorzeitig beenden. Gründe für den Abbruch waren die fehlende regelmäßige Teilnahme am Training aufgrund von Dienstreisen, die Priorisierung der Arbeit, Teilzeitbeschäftigung oder private Gründe (längerer Urlaub, Krankheit, Schwangerschaft). So schlossen 253 Teilnehmer (138m/115w) die Studie erfolgreich ab: 158 (102m/56w) in der Interventionsgruppe (IG) und 95 (36m/59w) in der Kontrollgruppe (KG) mit 58 Dropouts in der IG und zwei Dropouts in der KG. Die Probanden waren zwischen 20 und 63 Jahre alt.

2.2.2.2 Rekrutierung

Siehe Kapitel 2.2.1.2

2.2.2.3 Messsysteme

Siehe Kapitel 2.2.1.3

2.2.2.4 Studienprotokoll

Das Interventionsprogramm "five-Business" wurde von dem kommerziellen Anbieter FIVE-Konzept GmbH & Co. KG (Hüfingen, Deutschland) in Zusammenarbeit mit der Daimler Gesundheitsabteilung für die Umsetzung im betrieblichen Umfeld und für Gesundheitsförderung entwickelt. Das Programm umfasst fünf Dehnungsübungen des Rumpfes in zwei Freiheitsgraden auf einem speziell entwickelten Gerät. Alle Übungen lassen sich am Gerät im Stehen und in Arbeitskleidung durchführen. Höhenverstellbare Polster, die als Widerlager dienen, ermöglichen es, das standardisierte Programm individuell anzupassen. Die Teilnehmer absolvierten das Dehntraining zweimal wöchentlich für etwa 10 Minuten. Jede

Übung wurde zweimal für 20 Sekunden durchgeführt. Die Intervention war für eine Dauer von zwölf Wochen angesetzt, in denen 22-24 Trainingseinheiten durchgeführt wurden.
Um die Einhaltung einer regelmäßigen Trainingsbeteiligung unter Berücksichtigung der betrieblichen Arbeitsrealität (z. B. Urlaube, Auswärtstermine oder Arbeitsunfähigkeit) sicher zu stellen, wurden folgende Richtlinien festgelegt: (1) Die Teilnehmer durften maximal zwei Wochen am Stück abwesend sein; (2) nach ihrer Abwesenheit durften die Teilnehmer die fehlenden Trainingseinheiten mit einer zusätzlichen Einheit pro Woche kompensieren; und (3), die Teilnehmer durften insgesamt zwei der 24 Trainingseinheiten versäumen.
Um kurze Wege zum Trainingsgelände zu gewährleisten, wurden insgesamt vier Geräte genutzt: zwei im ersten Stock und zwei im dritten Stock des vierstöckigen Gebäudes. Der Trainingsbereich wurde durch 1,60 m hohe Trennwände abgeschirmt, um die Privatsphäre zu gewährleisten. Beide Trainingsbereiche waren ständig von ausgebildeten Trainern beaufsichtigt, um die korrekte Durchführung der Übungen zu gewährleisten. Fehlende Teilnehmer wurden per E-Mail kontaktiert, um einen neuen Termin zu vereinbaren. Die Studie wurde zwischen April und Juli 2018 durchgeführt. Aus trainingswissenschaftlicher Sicht kann das Programm "five-Business" dem statischen Dehnen zugeordnet werden, da die Muskulatur bei kontinuierlicher isometrischer Kontraktion statisch gedehnt wird. Die Dehnungsübungen sind Ganzkörperübungen, die den Rumpf in all seinen Freiheitsgraden, bis auf die Rotation, endgradig dehnen. Die Dehnübungen berücksichtigen die myofaszialen Ketten nach Myers [55] und wurden bereits im Rahmen des Behandlungskonzeptes der Rumpfextension von McKenzie [18,19] angewandt.
Der allgemeine Gesundheitszustand unter Verwendung des SF-36 Fragebogens wurde vor und nach der Intervention evaluiert. Der Fragebogen wurde vor Ort an einem zu diesem Zweck eingerichteten Computer ausgefüllt. Versuchspersonen, die nicht physisch anwesend sein konnten, durften den Fragebogen online ausfüllen. Das Training wurde während der gesamten Intervention von geschultem Trainingspersonal begleitet und kontrolliert. Die Kontrollgruppe führte die Befragung zwölf Wochen nach den Eingangsanalysen analog zur Interventionsgruppe durch.
Weitere Details zum Studienprotokoll können Kapitel 2.2.1.4 entnommen werden.

2.2.2.5 Statistische Auswertungsverfahren

Um die Prä-Daten zu vergleichen, wurden die Ergebnisse der SF-36-Subskalen aus dem Prä-Test der Interventions- und Kontrollgruppe den Ergebnissen der deutschen Normstichprobe aus 1994 gegenübergestellt. Zu diesem Zweck wurde die Normdatenerhebung nach folgenden Kriterien gefiltert: voll- oder teilzeitbeschäftigt (mindestens 15 Stunden), Angestellte mit Tätigkeit, die nach Anweisung erledigt wird, Angestellte mit selbstständiger Leistung in verantwortlicher Position, Angestellte mit umfassenden Führungsaufgaben, Realschulabschluss (Mittlere Reife), Fachhochschulreife oder allgemeine- oder fachgebundene Hochschulreife. Die endgültige Normstichprobe bestand aus 407 (186m/244w) Probanden mit einem Durchschnittsalter von 37 Jahren. Der Kolmogorow-Smirnow-Lilliefors-Test wurde verwendet, um die Normalverteilung der Messwerte zu überprüfen. Da fast alle Daten nicht normalverteilt waren, wurden nichtparametrische Tests angewendet. Zum Vergleich der Basisdaten der IG, KG und der deutschen Normstichprobe von 1994, wurde der Kruskal-Wallis-Test durchgeführt mit anschließenden Conover-Iman-Vergleichen und Bonferroni-Holm Korrekturen für multiple Vergleiche. Darüber hinaus wurden Effektstärken (eta^2=0,01 geringer Effekt, 0,06 mäßiger Effekt, 0,14 starker Effekt) berechnet. Für die statistische Analyse innerhalb der Gruppen wurde der Wilcoxon-Test für ordinale und der McNemar-Test für nominale Daten durchgeführt. Des Weiteren wurden die Messwerte zwischen der Interventions- und der Kontrollgruppe mittels des Wilcoxon-Mann-Whitney U-Tests verglichen. Der exakte Fisher-Test diente der Analyse von nominal skalierten Werten. Darüber hinaus wurden für jeden Test die jeweiligen Effektstärken berechnet. Um geschlechtsspezifische Differenzen zu testen, wurde der Wilcoxon-Mann-Whitney U-Test verwendet. Alle Tests wurden zweiseitig durchgeführt, mit einem Signifikanzniveau von = 5%. Für die statistische Auswertung wurde das Statistikprogramm "IBM SPSS Statistics 26" verwendet.

2.3 Ergebnisse der zweiten Publikation: Ein individueller und standardisierter Ansatz zur Verbesserung der Lebensqualität von Büroangestellten

Der Vergleich der Ausgangswerte der SF-36 Merkmale zwischen Interventionsgruppe, Kontrollgruppe und der deutschen Normstichprobe von 1994 zeigte, dass die KG in jedem Merkmal einen höheren Wert als die IG erzielte und mit Ausnahme von VITA, einen höheren Wert als die Normstichprobe hatte. Der Kruskal-Wallis-Test zeigte signifikante Unterschiede, aber insgesamt kleine Effektstärken zwischen den Baseline Werten in den Merkmalen KÖFU ($p<0{,}001$; eta^2=0,037), KÖRO ($p=0{,}047$; eta^2=0,01), SCHM ($p<0{,}01$; eta^2=0,02), AGES

(p=0,045; eta^2=0,01) und KSK (p<0,001; eta^2=0,014). Alle anderen Vergleiche waren nicht signifikant.
Die Wirksamkeit der Intervention wurde durch einen Vergleich der Prä-Post-Ergebnisse der Interventionsgruppe untersucht. Es wurden signifikante Verbesserungen in den Merkmalen KÖFU (p<0,001), KÖRO (p=0,03), SCHM (p=0,013), VITA (p<0,001), SOFU (p<0,001) und PSYC (p<0,001) beobachtet. Alle Subskalen zeigten Verbesserungen in der Punktzahl im Vergleich zum Ausgangswert, obwohl die Effektstärken als tendenziell gering einzustufen sind (0,04-0,26). Während die Ausgangswerte der Interventionsgruppe in den Merkmalen SCHM, VITA und SOFU in den Subskalen niedriger waren als in der deutschen Normstichprobe, führte die Intervention insgesamt zu signifikanten Verbesserungen der VITA und SOFU. Aufgrund der signifikanten Zunahme von SCHM liegt die IG nach der Intervention im Bereich der Norm. Sowohl die KSK als auch die PSK der IG zeigten im Vergleich zu den Ausgangswerten eine signifikante Verbesserung (KSK: p=0,009; PSK: p<0,001).
Für die Kontrollgruppe konnten keine signifikanten Verbesserungen im Vergleich zu den Ausgangswerten gemessen werden.
Die Prä-Post-Differenzen von IG und KG wurden verglichen. Ein signifikanter Unterschied lässt sich für die Subskalen KÖFU (p<0,001), SCHM (p=0,010), VITA (p=0,025), EMRO (p=0,018) und PSYC (p=0,012) feststellen. Für die Subskalen KÖRO, AGES und SOFU konnten keine signifikanten Unterschiede gefunden werden. Für jede Merkmalsausprägung wurde eine größere Verbesserung in der IG beobachtet. Die Gesamteffektstärken sind, analog zu den Vergleichen der Ausgangswerte, klein. Der Vergleich des körperlichen und des mentalen Gesamtpunktwerts zeigt signifikante Unterschiede für PSK (KSK: p=0,103; PSK: p=0,008).
Die Teilnehmer der Interventionsgruppe fühlten sich signifikant weniger gereizt (p=0,031), ihre Energie ließ signifikant weniger schnell nach (p=0,041) und die Sorgen hielten sie nachts signifikant kürzer wach (p=0,039).

2.4 Diskussion

Das Hauptziel dieser Studie war es, die Wirksamkeit des körperlichen Dehntrainings mit Hilfe eines Fragebogens zur gesundheitsbezogenen Lebensqualität zu untersuchen. Die Ergebnisse des Interventionskontrollvergleichs demonstrieren, dass in beiden erfassten Dimensionen durch das Training signifikante Verbesserungen eingetreten sind. Bei drei von vier psychologischen Subskalen (PSYC (p=0,012), EMRO (p=0,018) und VITA (p=0,025)) und zwei von vier körperlichen Subskalen (KÖFU (p<0,001) und SCHM (p=0,01)) wurden signifikante Verbesserungen festgestellt, was darauf hindeutet, dass das Dehntraining nicht nur die körperlichen Gesundheitsparameter, sondern auch die psychische Gesundheit beeinflussen kann. Diese Ergebnisse stehen im Einklang mit Studien, die über Zusammenhänge zwischen körperlicher Aktivität und psychischer Gesundheit bzw. gesundheitsbezogener Lebensqualität berichten [58-61].

Die Betrachtung der kumulativen Summenskalen zeigt, dass nur in der mentalen Summenskala (p=0,008) signifikante Verbesserungen auftraten, während die physische Summenskala (p=0,103) nicht signifikante Verbesserungen aufwies. Das psychische Wohlbefinden kann positiv durch weniger Schmerzen (SCHM p=0,009) und eine daraus resultierende Verbesserung der sozialen Teilhabe beeinflusst werden [62]. Des Weiteren scheint die Intervention die Probanden zu ermutigen, ihr eigenes Wohlbefinden zu beeinflussen und körperliche Beschwerden kontrollieren zu können (EMRO (p=0,018)). Darüber hinaus können die Gründe für das gesteigerte psychische Wohlbefinden in einem erhöhten Bewegungsumfang und damit in reduzierten Schmerzen liegen. Diese Hypothese kann durch signifikante Verbesserungen der körperlichen Schmerzen und der körperlichen Funktionsfähigkeit gestützt werden, was durch neuere Studien bestätigt werden kann [63-65]. Goncalves und Kollegen [64] fanden einen negativen Zusammenhang zwischen der Häufigkeit und Schwere von Nackenschmerzen und der globalen gesundheitsbezogenen Lebensqualität. Andere Studien haben gezeigt, dass Rückenschmerzen und insbesondere chronische Kreuzschmerzen mit einem höheren Grad an subklinischer Angst und Depression assoziiert sind [63,65]. Dehnen ist eine der vielen Methoden, die bei MSE, insbesondere bei Rückenschmerzen, empfohlen wird [66]. In den meisten Fällen verursachen Schmerzen im Zusammenhang mit MSE einen gewissen Grad an Einschränkung aufgrund des verminderten Bewegungsumfangs [67,68]. Daher könnte das Dehnen die Schmerzen in Zusammenhang mit MSE verbessern, indem es den Bewegungsumfang erhöht, die Blutzirkulation innerhalb der betroffenen Muskulatur verbessert oder die Ernährung der Bandscheiben verbessert [69]. Lawand et al. [70] berichteten über signifikante Befunde bei SF-36 Merkmalen SCHM, EMRO, KÖFU, VITA und PSYC unter Verwendung eines Dehnprogramms bei Patienten mit chronischen Kreuzschmerzen. In dieser Studie unterzogen sich 61 Patienten mit chronischen Kreuzschmerzen 12 Monate lang einer wöchentlichen 60-minütigen Dehnungssitzung. Diese Ergebnisse bestätigen die Ergebnisse der aktuellen Studie, da genau dieselben SF-36 Merkmale nach einer Dehnungsperiode von 12 Wochen signifikante Verbesserungen zeigten. Dies deutet darauf hin, dass Dehntraining auch bei Büroangestellten zu Vorteilen in der gesundheitsbezogenen Lebensqualität führt.

Tunwattanapong und Kollegen [13] veröffentlichten bisher die einzige Studie, die Parameter der gesundheitsbezogenen Lebensqualität in einer Dehnmaßnahme im Rahmen von betrieblichen

Gesundheitsförderung evaluiert haben. Sie berichteten über Verbesserungen der gesundheitsbezogenen Lebensqualität (KSK: $p<0,001$; PSK: $p=0,084$). Im Gegensatz zu den Ergebnissen von Tunwattanapong et al. [13] konnten in der vorliegenden Studie signifikante Verbesserungen in der PSK und in zwei der vier physischen Dimensionen demonstriert werden, nicht aber in der KSK. Dies könnte durch Unterschiede im Studienprotokoll bezüglich Übungsauswahl, Interventionsdauer oder Trainingseinheiten pro Woche erklärt werden; die Auswahl der Übungen unterscheidet sich erheblich. Während sich Tunwattanapong et al. [13] auf Übungen für den Nacken und die Schultern konzentrierten, wurden in der vorliegenden Studie hauptsächlich Übungen für ganze Muskelgruppen ausgewählt; diese ähneln Übungen aus dem Yoga. Hartfiel et al. [20] zeigten, dass arbeitsplatzspezifisches Yogatraining zur Reduktion von Rückenschmerzen und Stress sowie zur Verbesserung des Wohlbefindens beitragen kann. Es kann konstatiert werden, dass die vorliegende Studie demonstriert hat, dass Dehnübungen als BGF Maßnahme die gesundheitsbezogene Lebensqualität positiv beeinflusst.

Der Vergleich der absoluten Prä-Werte zwischen IG und KG zeigt, dass die Probanden in der IG in allen Dimensionen schlechtere Ausgangswerte hatten, dies gilt insbesondere für die körperlichen Skalen, denn nur hier waren die Unterschiede signifikant. Der Vergleich der Post-Werte zeigt, dass diese körperlichen Dimensionen auch nach der Intervention noch hinter denen der KG zurückblieben, während in den psychischen Aspekten überall bessere Werte als in der KG auftraten. Diese Einschränkungen in den körperlichen Dimensionen der Lebensqualität könnte darin begründet sein, dass die IG signifikant älter war als die KG ($p<0,010$), was darauf zurückzuführen ist, dass es sich um eine wartende KG handelte. Dennoch konnten auch in der IG signifikante Verbesserungen in drei von vier körperlichen Dimensionen erzielt werden.

Die Analyse der geschlechtsspezifischen Unterschiede legt nahe, dass das Geschlecht keinen Einfluss auf die Ausprägung der SF-36 Merkmale zu haben scheint. Demnach reagieren Frauen und Männer sowohl auf körperlicher als auch auf psychischer Ebene ähnlich auf Dehnung [71].

Bei der Interpretation der Ergebnisse muss jedoch angesichts der insgesamt geringen Effektstärken berücksichtigt werden, dass die Auswirkungen der Dehnung auf Dimensionen der gesundheitsbezogenen Lebensqualität trotz signifikanter Unterschiede vermutlich an der Schwelle zur klinischen Relevanz liegen. Andererseits ist die Effektgröße als Maß für Veränderungen in der Psychologie umstritten. Bei einem Test mit entsprechend hoher Power wie dem SF-36 könnte bei Effekten von 0,1 bis 0,2 von moderaten Effekten gesprochen werden. Insbesondere unter Berücksichtigung der vergleichsweise kleinen Gruppengrößen, scheint der p-Wert ein gutes Maß für den Interventionserfolg zu sein.

Zwar hätte eine zufällige Gruppenzuteilung eine homogenere Gruppenzusammensetzung begünstigt, allerdings hätte dies zu einer signifikanten Verringerung der Teilnehmerzahl geführt und die Durchführbarkeit der Studie gefährdet, weshalb eine Quasi-Kontrollgruppe gewählt wurde. Dennoch muss bei der Interpretation der Ergebnisse die fehlende Randomisierung berücksichtigt werden. So können beispielsweise Faktoren, wie langer Urlaub oder Abwesenheit, hohe Arbeitsbelastung oder Krankheit, die eine Zuordnung zur KG begünstigen, die Lebensqualität beeinflussen. Hinsichtlich der IG muss erwähnt werden, dass die individuelle Zuwendung des Trainerpersonals sich gegebenenfalls auf das Wohlbefinden auswirken könnte. Außerdem wäre es möglich, dass alleine die Pause unabhängig von der Dehnung zu einer verbesserten Lebensqualität geführt hat. Dies ist allerdings nicht zu erwarten, zumal mehrere Studien [72-74] gezeigt haben, dass sich aktive Pausen positiv auf Schulter-/Nackenschmerzen auswirken, was bei passiven Pausen nur eingeschränkt der Fall ist. Außerdem fällt auf, dass die berichtete Häufigkeit von Pausen viel höher ist als in der vorliegenden Studie. Es kann nicht ausgeschlossen werden, dass zwei Pausen von zehn Minuten pro Woche einen Effekt haben, jedoch ist es nicht zu erwarten. Nicht zuletzt könnte sich die bloße Möglichkeit der Teilnahme an einer entsprechend groß aufgezogenen Maßnahme im Sinne von Wertschätzung und Erleben einer positiven Unternehmenskultur positiv auf das Ergebnis ausgewirkt haben.

Geringfügige Änderungen mussten an der Methode vorgenommen werden (Holzgreve et al. [75]): Zwei Trainingseinheiten pro Woche konnten aufgrund von Urlaub, Sitzungen und Krankheit nicht eingehalten werden, sodass das Studienprotokoll angepasst werden musste (siehe 2.2.2.4). Weitere Einschränkungen können sich in der praktischen Anwendung ergeben, wenn das Training nicht mit entsprechend hohem Personalaufwand durchgeführt wird (1:2 Betreuung). Da eine erfolgreiche Umsetzung eines BGF-Programms von der Teilnahmebereitschaft der Mitarbeiter abhängt, sollte in zukünftigen Studien evaluiert werden, ob Dehntrainingsprogramme mit weniger Personalaufwand vergleichbare Ergebnisse erzielen. Darüber hinaus sollte in zukünftigen Studien beobachtet werden, ob eine zufällige Randomisierung und Pausen analog der Trainingszeiten in der Kontrollgruppe zu ähnlichen Ergebnissen führen.

3 Übersicht der zur Veröffentlichung angenommenen Manuskripte bzw. Publikationen

Holzgreve F, Maltry L, Lampe J, Schmidt H, Bader A, Rey J, Groneberg DA, van Mark A, Ohlendorf D. The office work and stretch training (OST) study: an individualized and standardized approach for reducing musculoskeletal disorders in office workers. *Journal of Occupational and Medical Toxicology* 2018;13(1):37. doi: 10.1186/s12995-018-0220-y.

Holzgreve F, Maltry L, Hänel, J, Schmidt H, Bader A, Frei M, Filmann N, Groneberg DA, Ohlendorf D, van Mark A. The Office Work and Stretch Training (OST) Study: An Individualized and Standardized Approach to Improve the Quality of Life in Office Workers. *International Journal of Environmental Research and Public Health* 2020;17(12):4522. doi: 10.3390/ijerph17124522.

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METHODOLOGY Open Access

The office work and stretch training (OST) study: an individualized and standardized approach for reducing musculoskeletal disorders in office workers

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Abstract

Background: Musculoskeletal disorders (MSD) are a common health problem in office workers. In Germany, MSD (mainly back pain related) are the main cause of workdays lost to incapacity. This is not only bothersome for the employees, but also causes higher costs for the health system and employers. Workplace health promotion programmes (WHPP) can help to reduce this as they reach large target groups and are easily accessible. In this context, stretch training exercises have already proven to be effective. In the present study, a new approach focusing on trunk extension is to be investigated.

Methods: To evaluate the training device "five-Business", 250 office workers will train two times a week for 3 months. The control group will consist of 100 office employees. The device "five-Business" enables five different full body exercises. The intervention will be evaluated before week one and after week twelve via three assessments: a) the Short Form-36 (SF-36) to record the general health status and health-related quality of life, taking into account physical, psychological and social factors, b) the Nordic Questionnaire to evaluate complaints of the musculoskeletal system, c) Range of Motion (ROM) measurements using a digital inclinometer and a measuring tape respectively.

Conclusion: The "five-Business" combines elements of yoga and the McKenzie fundamentals, taking into account the Myers myofascial pathways in a highly torso-oriented, standardized stretching program. Due to the given exercise execution on the device and the individual adjustment possibilities of the stretching position (body size and range of motion) by the abutment, all exercises are individualized and standardized at the same time. In comparison to existing stretching interventions, this is a new approach in the framework of reducing musculoskeletal disorders and improving the quality of life in workplace health promotion.

Background

In industrial nations, the service sector is the dominant economic sector [1, 2], where the majority of working time is spent in a sitting position [3]. About 50% of the employees suffer from moderate pain and about 30% from severe back and neck pain [4, 5]. Risk factors include years spent in an office [6], gender [5–7], body mass index (BMI) [7] and age [5–8]. The weighting of the influencing factors can vary depending on the cultural context, as observed in a comparison between Malaysian and Australian office workers [9]. If diseases of the musculoskeletal system (MSD) are not treated, this can ultimately lead to a greater number of work days lost to incapacity [6, 10–12]. One reason might be, that in physical therapy of MSD occupational factors are not consistently taken into account [13]. In Germany, MSD are the main cause of disability days [14, 15]. From 2011 to 2017, MSD-related diagnoses accounted for an average of 22% of all diagnoses [14]. These were mainly back pain related [15]. In the worst cases, these complaints can become chronic and the

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temporary inability to work can become an occupational disability. The high rate of MSD related absenteeism [14] is not only a burden for the employees, but also causes greater costs for employers and the health system. In 2016, the loss of gross value added caused by MSD in Germany amounted to 30.4 billion euros, which is equivalent to 1% of gross national income [16].

In the past, behavior oriented prevention and structural prevention in the form of WHPP appears to make sense, as they reach large target groups and are easily accessible [8, 17–19]. Usually these programmes pursue one of the following strategies: workplace optimisation, workplace policy changes (structural workflow, for example, standing meetings), provision of information (to improve lifestyle and physical activity levels) or multi-modal interventions [17, 20]. Interventions of this kind have been studied intensively. However, meta-analyses found only minor positive effects on physical activity [2, 8], reduction of sitting time [20], weight and lifestyle [8]. The study designs of the included studies were very inconsistent with regard to sample size ($n = 40$–924), intervention period (9 weeks to 2 years) [8], grouping and target sizes. In total, younger volunteers (≤40 years) seemed to benefit more in these studies [8].

Although they are far less extensively studied, instructed stretching programmes at the workplace offer a more promising approach [12, 21–24]. For example, the research of Tunwattanapong et al. [21] demonstrated a reduction in neck and shoulder complaints (– 1.4; 95% CI: -2.2, – 0.7 using the visual analogue scale) and an improvement in quality of life (14.0; 95% CI: 7.1, 20.9 using the physical dimension of SF-36). However, to our knowledge, the investigated programs were neither standardized nor individualized, which could be important if a heterogeneous population, such as the many employees present in an office building, is to be reached. Therefore, a new and more global approach, the "five-Business" stretch training programme ("Five-Konzept", Hüfingen, Germany), is presented in this study. Here, the exercises are executed on an adjustable wooden device (Fig. 1).

The objectives of the present study were to evaluate the "five-Business" stretch training programme in terms of its effects on ROM, its effectiveness in reducing MSD and its effects on the health-related quality of life.

"Five-Konzept"

Basically, the training method of "Five-Konzept" is a static and predominantly passive set of stretching exercises which is carried out on a special wooden device. Taking into account the course of the so-called myofascial pathways according to Myers [25], whole muscle chains are intensively stretched with isometric contraction. The focus of the exercise programme is on the musculature of the trunk, especially the extension of the spine, where the exercises partly resemble yoga positions.

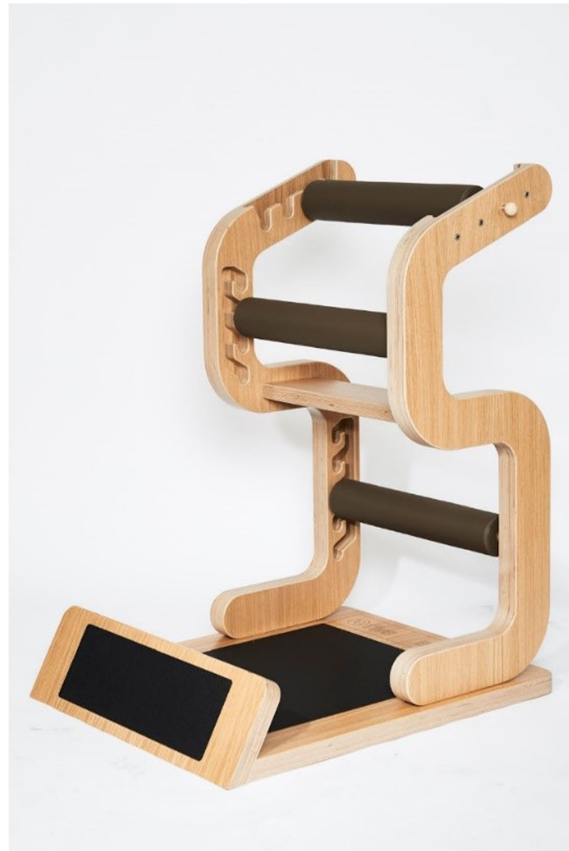

Fig. 1 Training Device "five-Business": The black rolls are adjustable to individual sice, flexibility and skill of the user

Since sitting usually involves flexion of the spine, these exercises can be seen as a counter-movement to sitting. This variable compression of the spinal discs improves their nutrition through diffusion [26]. For this reason, especially people with a sedentary lifestyle, such as office workers, can benefit from this programme.

Currently, this training method is mainly used by fitness providers throughout Germany, although no scientific studies of this new training concept have been published to date. However, it has already been shown that workplace-specific yoga training (Dru-Yoga) can contribute to the reduction of back pain and stress, as well as to the improvement of well-being (PANAS-X questionnaire) [27, 28]. The "five-Business" also includes the treatment in the trunk extension often recommended by McKenzie's treatment concept [29, 30].

A special device ("five-Business" device, see Fig. 1) was developed for the application of the "Five-Konzept" in the context of WHPP. The device allows an individual setting for all exercises and summarizes the "Five-Konzept" validly.

Although the method is named "active muscle length training" rather than "stretching" by the provider, the authors decided to use the term stretching as, from a physiological point of view, this is the correct term.

Aims
Chronic disorders, as a result of persistent complaints in the sense of upper and low back pain, are often associated with mood disorders and a poorer quality of life [31].

This pilot study will evaluate the effectiveness of systematic stretch training exercises of the trunk in office workers at the workplace. The influence of the training on the quality of life, the muscular skeletal discomfort and the mobility of the stretched structures will be investigated. On the basis of these results, it can then be evaluated to what extent the training is suitable as a WHPP measure.

Hypotheses
Hypothesis 1
A systematic, occupation-specific and guided stretch training programme ("Five Konzept") leads to an improvement of the quality of life.

Hypothesis 2
A systematic, occupation-specific and guided stretch training programme ("Five Konzept") leads to a reduction of MSD, especially in the lower back area.

Hypothesis 3
A systematic, occupation-specific and guided stretch training programme ("Five Konzept") leads to an increased mobility of the stretched structures.

Materials and methods
Subjects
Within the framework of the intervention control study, a total of 350 subjects aged between 18 and 65 years are to be measured, 250 of whom belong to the intervention group and a further 100 to the control group, the allocation being nonprobabilistic. All subjects work full-time at office workplaces. Exclusion criteria are subjects who have had relevant operations or who have surgical stiffening of the musculoskeletal system, relevant artificial joint replacement, severe diseases such as ankylosing spondylitis, chronic destructive joint diseases, multiple sclerosis, myodystrophic or neurodegenerative diseases, congenital malpositions of the musculoskeletal system or an acute herniated disc. In addition, the intake of muscle relaxants or other drugs that influence the elasticity of the musculature and pregnancy are considered contra indicators.

All participants will provide written informed consent to take part in the study in advance. The study is approved by the ethics committee of the Medical Faculty of the Landesärztekammer Baden-Württemberg (F-2017-073).

Recruitment
The program will be promoted via in-house e-mails from the health department of the respective company and, at the same time, the possibility of registering for the study will be offered. The registration period is set for 2 weeks. Afterwards, all potential participants will be contacted by telephone to clarify the exclusion criteria and to divide them into intervention groups based on availability.

Intervention program
The intervention program "five-Business" has been designed by the commercial provider "Five-Konzept" (Hüfingen/Germany) for the implementation in company settings and for health promotion. All exercises are performed standing on one machine, wearing shoes (for safety reasons subjects were not allowed to wear heeled shoes > 5 cm) and in "working clothes" (Fig. 1). The dimensions of the device are 116 cm × 82 cm × 128 cm and the weight is 60 kg.

The subjects perform the following 5 exercises: (1) Stand, (2) Chest, (3) Ischio, (4) Hip and (5) Lateral.

1. Stand: In the exercise "stand", knee, hip, lumbar spine and thoracic spine are extended to the maximum (Fig.2).
   The cervical spine, on the other hand, is flexed. Following the myofascial meridians after Myers [25], structures of the superficial frontal line (SFL) ((sternalis muscle), sternochondral fascia, rectus abdominis muscle, quadriceps femoris muscle in particular rectus femoris muscle and patellar tendon) are statically passively stretched. For the sake of completeness, a selection of structures of the deep frontal line (DFL), which are potentially strained due to the direction of movement, are listed below (endothoracic fascia, transversusthoracis muscle, pericardium, mediastinum, parietal pleura, diaphragm, anterior longitudinal ligament, sacral fascia, psoas muscle, iliac muscle, pectineus muscle, femoral triangle, medial intermuscular septum of the thigh, adductor brevis muscle and adductor longus muscle). By increasing the torque (e.g. by raising the arms), both the strain stress and the isometric contraction of the stretched musculature can be increased.
2. Chest: A back bend is carried out analogous to "Stand" and "Hip". The abutment is positioned at the level of the shoulder blades; this brings the strain stress especially to the chest area. Structures of the deep frontal armline (DFA) [25] (minor pectoralis muscle, clavipectoral fascia, biceps brachii muscle, anterior edge of the radial periosteum, muscles of the ball of the thumb and radial collateral carpia), of the superficial frontal armline (SFA) [25] (pectoralis major muscle, latissimus dorsi muscle, septum intermusculare brachii mediale, flexors and carpal tunnel), the functional frontal

Fig. 2 All 5 exercises of the "five-Business": exercises in the order of execution: 1) Stand, 2) Chest, 3) Ischio, 4) Hip and 5) Lateral

line (FFL) [25] (pectoralis major muscle, rectus abdominis muscle and adductor longus muscle), as well as the upper SFL and DFL, are stretched. By actively returning the arms, the stretching stress in the chest area is increased so that the exercise can mainly be assigned to active static stretching.

3. Ischio: Static passive stretching of the entire superficial back line (SBL) [25] (galea aponeurotica, epicranial fascia, sacrolumbar fascia, erector spinae muscle, sacrotuberous ligament, ischiocrural musculature, gastrocnemius muscle, achilles tendon, plantar fascia and short toe flexors) is performed by extension in the ankle and knee joints, as well as flexion in the hip and spinal column.
4. Hip: In principle, the same structures are used as for "Stand" (SFL/DFL). A special feature is the arbitrary isometric contraction of the agonists. This is ensured by strong pressing of the hung-up foot. The focus of the "Hip" exercise is on the strain on the hip-bending muscles and the associated structures.
5. Lateral: During lateral flexion, passive static stretching is performed under consideration of the lateral line (LL) [25] (splenius capitis muscle, sternocleidomastoid muscle, intercostal internal/external muscle, obliquus internal/external muscle, gluteus maximus muscle, gluteus medius muscle, tensor fascia latae muscle, iliotibial tract, anterior ligament of the head of the fibula and the peroneus longus/previs muscles). The torque can be increased by elevating both arms or holding weights above the head. This results in both increased stretching stress and increased isometric contraction of the stretched musculature.

Questionnaires

Nordic questionnaire

The Nordic Questionnaire records complaints of the musculoskeletal system and was developed by Kuorinka et al. in 1987 [32]. It has been validated and is used internationally in a wide variety of occupational groups such as administrative occupations [33–36], factory workers [37–40] or health professions [41–44]. Basically the Nordic Questionnaire asks general information, questions about the person, habits and work situation, but also provides overviews - divided into body regions - of the 7-day and 12-month prevalence of complaints, as well as the lifetime prevalence of complaints and functional impairments to date. Finally, it provides information on the focal points [1] neck, [2] shoulder and [3] lumbar spine in terms of the duration and frequency of complaints, impairment of work and leisure activities, as well as doctor consultation and the inability to work. This questionnaire is aimed at chronic and acute complaints of the musculoskeletal system, consisting of a 7-page survey which can be completed by ticking the appropriate box and which takes 15 to 20 min to complete.

Sf-36

The Short-Form-36 questionnaire (SF-36), developed by Ware and Sherbourne in 1992 in the United States [45], measures the general health status and health-related quality of life, taking into account physical, psychological and social factors. Currently, the SF-36 is widely used internationally [46–50]. The test residual reliability of the German version of the SF-36 varies over the individual subscales between $r = .67$ and $r = .85$. In a study with back pain patients ($n = 243$), the internal consistencies for all subscales were determined ($\alpha = .60–.93$) [51]. For the change sensitivity in lumbar back pain, low to moderate effect sizes are reported for the individual subscales (Standardized Effect Size (SES): (1).48; (2).13; (3) .20; (4) .39; (5).75; (6).28; (7).58; (8).21; (9)-.09; (10).32) [52]. The questionnaire responses are recorded as individual items and as sum scores, listed in a data table which serves as a basis for further statistical analysis.

Range of motion measurements

Range of Motion measurements are used to evaluate the effectiveness of the individual exercises with regard to changes in the stressed active and passive structures. The selection of the tests to be used are congruent with the stretched muscle chains of the individual exercises (Fig. 1). Two different measuring methods are used to measure the degree of mobility: a measuring tape (exercises 3 & 5) [53–58] and a digital inclinometer (exercises 1, 2 & 4) [59–69]. The digital inclinometer (Model: Acumar™ DIGITAL INCLINOMETER Model ACU002 / Lafayette Instrument Company / Lafayette / USA) is equivalent to the goniometer in terms of measurement accuracy [60], but is also superior in some validation studies (interrater reliability ($r = .92$ to $r = .53$ [66], intrarater reliability [60, 67]. Antonaci and colleagues [59] recommend the use of a digital inclinometer in clinical investigations. Reliability studies for shoulder mobility report an intrarater correlation between ICC = .65 and ICC = .96 [62, 64, 68]. Intrarater correlations between $r = .89$ and $r = .94$ were found for cervical spine mobility [63]. For interrater reliability, correlations between ICC = .58 and ICC = .95 for the shoulder [62, 64, 65] and between $r = .81$ and $r = .84$ [63] for the cervical spine were given. For the responsivity of the shoulder, Valentine and Lewis [68] were able to determine measurement errors of 1.3° for external rotation, 2.3° for internal rotation, 4.8° for abduction and 3.9° for flexion, thus, changes from 5° - 10° can be measured. Furthermore, Kolber et al. [65] determined the smallest detectable interrater difference (MDC (90)) to be 8° (flexion), 4° (abduction), 9° (external rotation) and 8° (internal rotation).

The sports engine tests are listed according to the sequence of measurements to be carried out.

Shoulder test modified after Janda

This test is intended to show changes caused by the exercise "Chest". In order to determine the mobility of the shoulder joint, especially of the pectoralis major muscle, the Janda examination is performed in a modified form [70]. In contrast to Janda, the elbow is stretched and the inclinometer is placed proximal to the processus styloideus radii on the radius. The measurement of the middle and upper sternal part of the pectoralis major muscle is carried out at approximately 90° abduction and rotated outside.

Modified Thomas test

The modified Thomas test is used to check for changes in flexibility in the hip-bending musculature. High interrater reliability ranges are given for the use of an inclinometer and goniometer have been determined ($r = .91–.93$; ICC = .89–.92). The intrarater parallel-forms reliability for the measurements made by the same examiner with both measuring instruments is $r = .89–.92$; ICC = .91–.93 [69]. In order to obtain valid results, the pelvic inclination must be controlled [71]. The pelvic inclination was standardized by placing the digital inclinometer from the anterior superior iliac spine downwards. In this position, the alignment of the pelvis is set to 0°. The inclinometer is then placed on the thigh, above the patella, to determine the joint angle.

Retroflexion of the trunk after Janda in the modified version

The retroflexion of the lumbar spine and thoracic spine, in particular, is checked by means of the modified retroflexion test according to Janda [70]. Since both ends of this range of motion are difficult to fix, angle measurement is only possible with difficulty. In order to counteract pelvic rotation in the sagittal plane, the pelvis was fixed to the treatment couch at the level of the posterior superior iliac spina with a tensioning strap. Furthermore, unlike Janda, the angle of the elbow is not used as a parameter for torso extension, but the position of the thoracic spine in the sagittal plane is determined by placing the inclinometer on the sternum.

Fingertip-to-floor test

The "fingertip-to-floor" test is used to evaluate the "Ischio" exercise. The aim is to assess the mobility of the back, both hips, the ischiocrural musculature and the neuromeningeal structures. The changes are measured using a conventional measuring tape. The reliability lies between $r = .76$ and $r = .99$ [53, 54, 56, 72] and shows a good sensitivity for changes [55].

Lateral inclination

The test of the lateral inclination evaluates the "Lateral" exercise. This is measured by the maximum lateral inclination with a standardized stand position. Sagittal fluctuations in the lateral inclination are eliminated by leaning the back against a wall. The lateral finger-to-ground distance is measured using a measuring tape [66].

Measurement protocol

The intervention study is scheduled to last 12 weeks. In the week before and the week after the study, the Range of Motion measurements and the surveys (Nordic Questionnaire and SF-36) will be carried out. For reasons of practicability, a randomization of the measurement sequence is deliberately omitted. The test persons complete the stretch training twice a week for approximately 10 min. Each exercise is held twice for 20 s; the time period is measured with a timer. The training is accompanied and controlled by trained trainer personnel throughout the intervention and only one-to-one supervision takes place. Where possible, attention is also paid to progressive load control; for this purpose, the training device is marked in advance so that the device setting and the stand position can be registered over the course of the training.

In order to be able to trace actual changes back to the intervention, the test persons must keep a training diary in order to identify influences from private physical activities. Since, over a total period of 14 weeks, including days for holidays, illness and business trips, it is not possible for office workers to participate consistently in training both during the study and in real working life.

Therefore, two goodwill appointments are offered so that at the end of the intervention period the test persons must have completed 22–24 training appointments. In the control group, the Range of Motion measurements and surveys (Nordic Questionnaire and SF-36) are carried out at 12-week intervals, analogously to the intervention group.

In order to achieve the most accurate measurement results possible, the measurements should always be carried out by the same experienced investigator [62, 73]. All measurements are performed three times, from which the mean value is calculated for further statistical analysis [74].

Evaluation criteria

The units of measurement are centimetres and degrees, as well as sum scores and information from the questionnaires according to the respective question.

Statistical data analysis

The statistics program "IBM SPSS Statistics 25" is used for the statistical evaluation. Firstly, all collected data are tested for normal distribution with the Kolmogoroff-Smirnoff-Lilliefors-Test.

For normally distributed data, the T-test is used for paired samples, whilst for non-normally distributed data, the Wilcoxon matched pairs test is used (hypotheses 1 & 3). Since the results of the Nordic Questionnaires are nominal or ordinal, the Chi-square test is used to test hypothesis 2 for independent group comparisons. In the pre-post comparison, the McNemar test for paired samples, or the Cochrans-Q test for repeated measurements, is performed.

The independent T-test (normally distributed) and the Wilcoxon-Mann-Whitney-U-test (non-normally distributed, metric and ordinal) are used to compare the values between the intervention and control groups for metric values. The Chi-square test is used to check nominally scaled values.

Furthermore, correlations between complaints, changes in range of motion and quality of life, are to be tested. For this purpose, the Pearson correlation is performed for normally distributed values and the Spearman correlation for non-normally distributed values.

The statistical evaluation is carried out under the supervision and advice of Dr. J. Rey (Institute for Biostatistics and Mathematical Modelling of the Medical Department of the Goethe University Frankfurt).

Discussion

The combination of elements of yoga and the McKenzie fundamentals, taking into account the Myers myofascial pathways in a highly torso-oriented, standardized stretching program, could provide new approaches to reducing MSD and improving the quality of life in workplace health promotion [25, 27–30]. Device-supported mobility training is suitable for integration into everyday office life as it can be carried out quickly and easily on a single device (TÜV tested). Due to the given exercise execution on the device and the individual adjustment possibilities of the stretching position (body size and range of motion) by the abutment, all exercises are individualized and standardized at the same time. Thus, it can also be used for heterogeneous groups in terms of physical proportions and capabilities. This is also an advantage over the stretching interventions evaluated so far [12, 21–24]. Shariat et al. [12, 23] evaluated 13 stretching exercises for the neck, shoulders and trunk, which were demonstrated in a video clip. After a two-week familiarization phase, the subjects trained three times a week with progressive exercise duration. A supervisor was available for questions and occasional monitoring. After eleven weeks, a reduction in pain in the trained areas, greater mobility and less perceived exertion could be observed. Using similar stretching exercises, Tunwattanapong et al. [21] also found positive effects in reducing neck pain and improving quality of life. However, the intervention group also received parallel instructions on ergonomic sitting. It is, therefore, unclear as to what influence the stretching had itself. However, the improvements observed were greater in subjects who had stretched at least three times a week than in those who had trained less frequently. In both interventions, the exercises were neither individualized nor standardized. In addition, a broad approach was chosen in both cases, taking into account not only the trunk but also the shoulders/arms and neck. The approach of a short, mainly torso-oriented stretching training exercise using myofascial muscle chains has not yet been investigated.

This stretch training exercise, developed for recreational sports, is now to be used within the framework of a WHPP to stretch muscle chains as a whole (especially in the trunk and hip area), which remain in a flexed position for several hours a day by sitting for long periods in a rigid, unfavorable manner. Despite the positive evidence described for the efficacy of similar stretching exercises, scientific studies have not found any connection between sitting per sé and low back pain [75] so far. Whether this also applies to other forms of MSD has not yet been clarified. Nevertheless, a concrete comparison of the known stretching techniques and the "five Business", with regard to the influence on the quality of life and prevalence of MSD, should be sought in the future.

A main problem concerning the implementation of WHPP is the small number of participants in relation to the workforce addressed (2–60%) [8] and, also the long-term motivation of the employees. A device installed on site, that promotes an intuitive execution of the exercise and functions as a constantly present "reminder" of the training itself, could promote compliance. In further studies, it should be examined whether the "five-Business" is superior to conventional stretching in this respect. This could also depend on the individuals psychosocial workplace risk, which can be assessed using the Short Questionnaire for Workplace Analysis (KFZA) [76]. Overall, as the physical constitution of office workers cannot be changed and the postural demands can not be significantly altered, it is advisable to optimize health prevention, such as has already been the case with exposure factors in physiotherapists [77] and musicians [78].

Limitations

An evaluation of the intervention, by means of the Range of Motion measurements, only records a change in mobility in the form of an altered movement amplitude. Through the application of the intervention, not only improvements in extensibility but also changes in strength, especially in isometric strength, can be expected. An effective measurement of the isometric maximum force is not planned for reasons of methodical implementation (material, temporal and spatial resources). Since the exercises Stand, Chest and Hip (with the exception of slightly different focal points) all include the back bend, no clear tests can be assigned to these exercises. Instead, in order to determine in which structure any changes occur, the hip and spine mobility in the extension direction is tested separately. Therefore, the modified Thomas test is used to examine the hip-bending musculature, while retroflexion of the trunk increasingly focuses on the mobility of the lumbar and thoracic spine. In addition to the modified shoulder test according to Janda, it should be noted that the determined joint angle includes the mobility of the elbow. This is particularly important in cases of muscular limitation of the elbow extension.

It should be noted that the muscle chains postulated by Myers have not yet been sufficiently investigated. Although there is strong evidence for SBL and FFL and moderate to strong evidence for LL, there is still no evidence for the existence of SFL [79].

When measuring mobility, the time of day plays a decisive role. Accordingly, the fingertip-to-floor distance decreases significantly in the course of the day [80]. A standardization of the time of day will only be possible approximately, in view of the availability of the office employees. Furthermore, an optimally standardized regular participation over a period of 3 months is not possible within the framework of such a study, since days lost due to the incapacity to work or to business or private travel cannot be avoided. Accordingly, the internal validity is not optimal. However, it should be noted at this point that no higher internal validity can be expected if the programme is implemented in the daily work of office employees. In this context motivation and experience of pain is unlikely to be homogenous in all subjects.

In the standardized Nordic Questionnaire, the 12-month pain prevalence is a fixed component. At this point, the query of the 3-month pain prevalence according to the intervention period would increase the change sensitivity. However, a modification of the questionnaire would entail a new evaluation on the one hand, whilst, on the other hand, this would make a comparison with other study data more difficult.

Conclusion

This projects aims to provide health management departments information on whether a standardized and individualized stretch training exercise has an impact on MSD of the staff. Effective programs are necessary to reduce the high number of work days lost due to incapacity with MSD. Apart from the self reported MSD and quality of life, it is a further goal of this study to investigate if the training affects physiologically measurable ranges of motion. Based on these outcomes, health managers will obtain evidence-based information on which they can decide whether the program is suitable for their company.

Abbreviations

BMI: Body Mass Index; DFA: Deep Frontal Armline; DFL: Deep Frontal Line; FFL: Functional Frontal Line; LL: Lateral Line; MDC: Smallest detectable interrater difference; MSD: Musculoskeletal Disorders; ROM: Range of Motion; SBL: Superficial Back Line; SES: Standardized Effect Size; SF-36: Short Form 36; SFA: Superficial Frontal Armline; SFL: Superficial Front Line; WHPP: Workplace Health Promotion Programs

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Availability of data and materials

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Authors' contributions

FH, LM and JL made substantial contributions to the conception and design of the manuscript. FH, LM, JL, DO, AVM made substantial contributions to the construction of the measurement protocol. HS and AB made substantial contributions to structural and executional aspects of the study protocol. JR has been involved in the statistical data analysis. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

All participants will sign an informed consent to take part in the study in advance. The study is approved by the ethics committee of the Medical Faculty of the Landesärztekammer Baden-Württemberg (F-2017-073).

Consent for publication

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Competing interests

The authors declare that they have no competing interests.

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Article

The Office Work and Stretch Training (OST) Study: An Individualized and Standardized Approach to Improve the Quality of Life in Office Workers

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Abstract: In the context of workplace health promotion, physical activity programs have been shown to reduce musculoskeletal diseases and stress, and to improve the quality of life. The aim of this study was to examine the effects of using the "five-Business" stretch training device for office workers on their quality of life. A total of 313 office workers (173m/137f) participated voluntarily in this intervention–control study with an average age of 43.37 ± 11.24 (SD) years, 175.37 ± 9.35 cm in height and 75.76 ± 15.23 kg in weight, with an average BMI of 24.5 ± 3.81 kg/m^2. The participants completed the stretch training twice a week for approximately 10 min for a duration of 12 weeks. The SF-36 questionnaire was used to evaluate the effectiveness of the intervention at baseline and after 12 weeks. Significantly improved outcomes in mental sum score ($p = 0.008$), physical functioning ($p < 0.001$), bodily pain ($p = 0.01$), vitality ($p = 0.025$), role limitations due to physical problems ($p = 0.018$) and mental health ($p = 0.012$) were shown after the stretching training. The results suggest that a 12-week stretching program for office desk workers is suitable to improve significantly their health-related quality of life.

Keywords: occupational health; workplace health promotion; quality of life; stretching; musculoskeletal disorders; SF-36; Five-Konzept

1. Introduction

The progressive tertiarization of the economy sectors increases psychological demands and strains in the occupational setting [1]. In this context, increasing competition and rising productivity are leading to an increasing stress level, which in turn can have an impact on the health-related quality of life (QoL). The health-related QoL also correlates with sickness absenteeism and lower presenteeism [2,3]. Besides psychological components, physical complaints and diseases, such as musculoskeletal disorders (MSD), are also associated with health-related QoL [4,5]. For instance, chronic neck and shoulder pain lead to low work ability and poor quality of life [6]. MSD have great socioeconomic impact as they affect people's wellbeing and welfare as well as reduce productivity [7].

Da Costa et al. [8], in a systematic review, identified that heavy physical work, smoking, high body mass index, high psychosocial work demands and the presence of comorbidity are risk factors with at least reasonable evidence for work-related MSD.

In Germany, MSDs are responsible for the 10 most important types of disease in disability days (20.9%), followed by sickness of the respiratory system (16.0%) and mental illness (15.2%) [9]. Since most diseases of the respiratory system are rather mild with an average case duration of 6.9 days, they are consequently rather short in comparison to MSD (19.7 days) and mental illness (37.0 days) [1]. In addition, the distribution of production downtime costs according to diagnosis groups was led by MSD (EUR 17.2 billion), followed by mental illness (EUR 12.2 billion) and respiratory system (EUR 10.6 billion) [10].

Employers seek to improve their employees' health in order to reduce costs and increase productivity. One approach in occupational safety and health are workplace health promotion programs (WHPPs) [11]. Common approaches focus on nutrition [12], lifestyle [13], weight [14] or physical activity programs [15–17]. Predominantly, it has been the physical activity programs that have been shown to reduce MSD and stress and to improve the health-related QoL in both young and old workers [18–21]. In addition, there are investigations that physical activity can positively influence the state of mental illness [22,23]. Considering the effectiveness of reducing neck pain, strengthening exercises seem to be favored. For instance, in a systematic review performed by Sihawong et al. [24], strong evidence was found for the effectiveness of strengthening and endurance exercises in neck pain reduction. A recent meta-analysis of Louw et al. [25] revealed level II evidence for strengthening exercises in treating neck pain but not for improving QoL. Nevertheless, the authors concluded that the effect of endurance and stretching exercises needs to be explored further. In a recent review from Van Eerd et al. [26], moderate effects were found for stretching exercise programs and strong evidence for strengthening exercises in preventing upper extremity MSD.

However, to date, most studies have evaluated the effectiveness of stretching programs for MSD outcomes, only few have investigated the influence of such methods on the health-related QoL so far. Tunwattanapong et al. [15] conducted a regular stretching program, consisting of shoulder and neck stretching exercises, which were performed two times/day for five days/week over four weeks. They reported significant improvements in the pain visual analog scale, Northwick Park Neck Pain Questionnaire and Short-Form-36 questionnaire (SF-36). Stretching exercises lead to a reduced muscle stiffness of the musculotendinous unit and consequently, to an improved flexibility of both active and passive physiological structures [27]. This can reduce stress and/or pain [28,29]. Since the health-related QoL is associated with physical activity, MSD, stress and mental complaints, health-related QoL is a valid parameter with which to measure the effectiveness of WHPPs. In order to quantify the health-related QoL, the internationally widely used and standardized SF-36 questionnaire is appropriate, which has been applied to a number of different occupational groups [30,31] and inter alia to patients with low back pain [32] or psychiatric patients [33,34].

"Five-Konzept" is a new WHPP approach, which comprises a stretching health prevention program for office workers. Within 10 min, five specific trunk exercises were carried out on a special device (five-Business) at least two times a week. Further details can be found in Holzgreve et al. [35].

The aim of this study was to examine the effects of the "five-Business" stretch training for office workers on the health-related QoL. First, the baseline results of the SF-36 surveys of the intervention and control group were compared with the results of the German norm sample in order to obtain information on the general state of health of these office workers. Secondly, the effects of stretching training were examined in an intervention–control study using SF-36 outcomes.

2. Methods

2.1. Subjects

A total of 313 office workers (173m/137f) in one of several buildings of a large automotive company voluntarily participated in this intervention–control study (Figure 1). Moreover, 19.2% (35m/22f) of the participants of the intervention group had to terminate the study prematurely. Reasons for the dropout were most commonly because of the lack of regular participation in training due to business trips, the priority of work, part-time employment or private reasons (longer holidays, illness, pregnancy). Thus, 253 participants (138m/115f) successfully completed the study: 158 (102m/56f) in the intervention group (IG) and 95 (36m/59f) in the control group (CG) with 58 dropouts in IG and 2 dropouts in CG. Subjects were aged between 20 and 63 years (Figure 1; Table 1). Two months before the start of the study, 1958 office employees were contacted by email via the company's internal health department. The aim was to reach healthy employees as well as employees with mild musculoskeletal complaints aged 18–65 years. All interested participants were contacted by telephone to clarify whether they met all the requirements and to arrange an appointment for the baseline testing. After baseline testing, the subjects were allocated to either the intervention or control group based on their availability. A total of 12.9% of the employees primarily contacted successfully completed the study (Figure 1).

Further socio-demographic characteristics can be taken from Table 1 on a gender-specific basis.

Exclusion criteria comprised relevant surgeries or surgical stiffening of the musculoskeletal system, relevant artificial joint replacement, severe diseases such as multiple sclerosis, myodystrophic or neurodegenerative diseases, congenital malpositions of the musculoskeletal system or an acute herniated disc. In addition, the intake of muscle relaxants or other drugs that influence the elasticity of the musculature, and pregnancy were considered as contra indicators. Participants met inclusion criteria when they were 18–65 years of age, worked in the office and were available during the offered training schedule. Further details can be found in the corresponding methodology article [35]. All participants signed written informed consent.

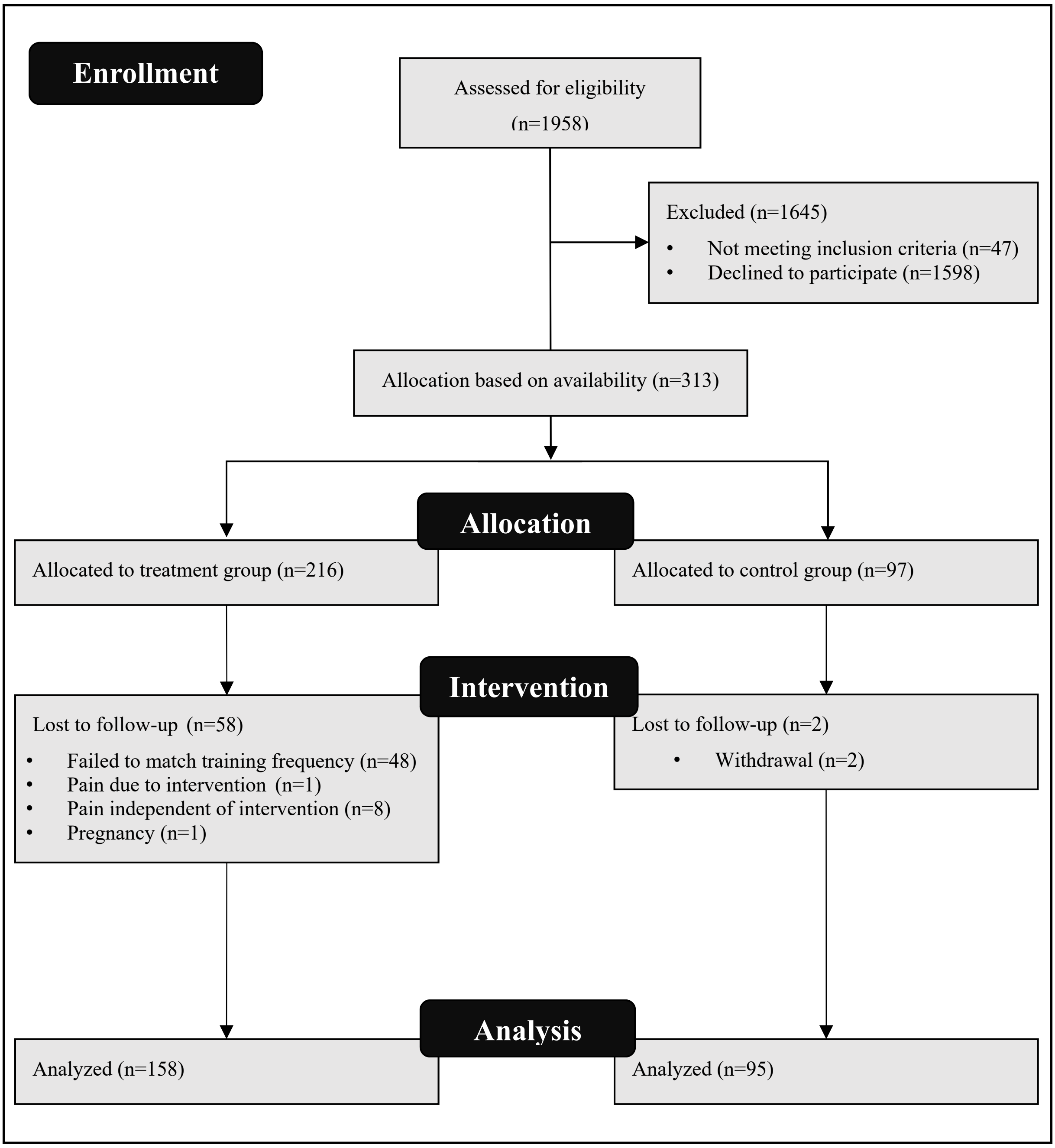


Figure 1. Disposition of study participants.

Table 1. Baseline demographic characteristics of participants in the intervention and the control groups. Significant differences in the baseline between IG and CG are marked with asterisks.

	Entire Sample [Mean (SD) or %]			Intervention Group [Mean (SD) or %]			Control Group [Mean (SD) or %]		
		Male	Female		Male	Female		Male	Female
Initial participants	n = 313	n = 172	n = 137	n = 216	n = 135	n = 78	n = 97	n = 38	n = 59
Dropouts	n = 60	n = 35	n = 22	n = 58	n = 33	n = 22	n = 2	n = 2	n = 0
Final participants	n = 253	n = 138	n = 115	n = 158	n = 102	n = 56	n = 95	n = 36	n = 59
Age (years) **	43.37 (11.24)	46.74 (10.21)	39.32 (11.11)	44.94 (10.56)	47.42 (9.52)	40.33 (10.84)	40.83 (11.92)	44.86 (11.86)	38.37 (11.37)
Height (cm)	175.37 (9.35)	180.34 (7.18)	169.41 (8.10)	176.21 (8.76)	180.78 (6.24)	167.89 (6.21)	173.98 (10.15)	179.11 (9.36)	170.85 (9.38)
Weight (kg) ***	75.76 (15.23)	82.90 (13.51)	67.12 (12.52)	78.15 (15.02)	83.83 (13.19)	67.43 (12.49)	71.97 (14.74)	80.25 (14.23)	66.83 (12.64)
BMI (kg/m^2) **	24.50 (3.81)	25.45 (3.64)	23.35 (3.71)	25.03 (3.97)	25.64 (3.74)	23.90 (4.18)	23.61 (3.35)	24.89 (3.34)	22.81 (3.13)
Handedness (% right)	94.90	94.20	95.70	93.70	94.10	92.90	96.80	94.20	98.30
Doing sports (% yes)	72.70	72.50	73.00	70.90	70.60	71.40	75.80	77.80	74.60
Smoking (% non-smoker)	88.90	90.60	87.00	89.90	92.20	85.70	96.80	86.10	88.10
h/sports/week ***	3.13 (3.01)	3.2 (3.17)	3.04 (2.80)	2.77 (3.17)	2.97 (3.29)	2.41 (2.92)	3.96 (2.45)	4.04 (2.56)	3.90 (2.40)

Cross-gender test for baseline differences between IG and CG. $p < 0.01$ = **; $p < 0.001$ = ***.

2.2. Intervention Program

The intervention program "five-Business" has been designed by the commercial provider Five-Konzept GmbH & Co. KG (Hüfingen, Germany) in cooperation with the Daimler health department for the implementation in company settings and for health promotion. The program comprises five stretch exercises of the trunk in two degrees of freedom on a specially developed device (Figure 2). All exercises can be performed on the device while standing and in business clothing. Height-adjustable cushions, which serve as abutments, allow the standardized program to be individually adapted. The participants complete the stretch training twice a week for approximately 10 min. Each exercise was held twice for 20 s. The intervention was scheduled for a duration of 12 weeks in which 22–24 training sessions were carried out. In order to meet the challenge of training on a regular basis, while still reflecting the operational reality of employees missing (e.g., due to vacation, business trips or sickness), the following guidelines were set: (1) the participants were allowed to be absent for a maximum of 2 weeks at a time; (2) after their absence, the participants were allowed to compensate for the missing training units with one additional unit per week; and (3), participants were allowed to miss a total of 2 out of the 24 training units.

Figure 2. All five exercises of the "five-Business" workplace health promotion program. Exercises in the order of execution: (1) Stand, (2) Chest, (3) Ischio, (4) Hip and (5) Lateral.

In order to guarantee short walking distances to the training area, four devices in total were used: two on the first floor and two on the third floor of the four story building. The training area was screened off by partitions that were 1.60 m in height to ensure privacy. Both training areas were permanently supervised by an experienced trainer to guarantee the correct execution of the exercises. Missing participants were contacted via email to schedule a new appointment. The study was carried out between April and July 2018.

In terms of the training science, the "five-Business" program can be assigned to static stretching, since the musculature is statically stretched with continuous isometric contraction. The stretch exercises are whole body exercises, focusing on the trunk; they partly resemble yoga positions. The stretching was designed according to the course of the myofascial pathways, as stated by Myers [36] and include recommendations by McKenzie within the framework of the treatment concept in the trunk extension [37,38].

2.3. Short Form 36

The SF-36 version 1.3, developed by Ware and Sherbourne in 1992 in the United States [39], measures general health and health-related QoL taking into account physical, psychological and social factors. It is used to evaluate the individual patients health status, researching the cost-effectiveness of a treatment or for monitoring and comparing disease burden [40]. With 35 items, the SF-36 records eight dimensions of subjective health: *physical functioning* (PF), *role limitations due to physical problems* (RP), *bodily pain* (BP), *general health perceptions* (GH), *vitality* (VT), *social functioning* (SF), *role limitations* *due to emotional problems* (RE) and *mental health* (MH). The eight subscales can be assigned to two basic dimensions of subjective health: *physical* and *mental health* (PSC and MSC). The lower the score, the more disability [40] the subject possesses. The reliability of the German version of the SF-36 varies over the individual subscales between r = 0.67 and r = 0.85. In a study with back pain patients (n = 243), the internal consistencies for all subscales were determined (Cronbach's α 0.60–0.93) [40]. In addition, 38 dichotomous questions on the health-related QoL were carried out as part of the survey.

2.4. Measurement Protocol

The general state of health using the health-related QoL survey SF-36 was evaluated before and after the intervention. The questionnaire was filled in on-site on a computer set up for this purpose. Subjects who could not be physically present were allowed to fill in the questionnaire online. The training was accompanied and controlled by trained trainer personnel throughout the intervention. The control group conducted the survey 12 weeks after baseline measurements analogous to the intervention group. The survey was used in April and July 2018.

2.5. Statistical Analysis

In order to compare baseline data, the results of the SF-36 subscales from the pre-test of the intervention and control group were compared with the results of the German norm sample from 1994 [40]. For this purpose, the standard data collection was filtered according to the following criteria: working full or part time (at least 15 h), employee with activity performed according to instructions, employee with independent performance in responsible position, employee with comprehensive management responsibilities, vocational training, polytechnic or university degree. The final norm sample consisted of 407 (244f/186m) subjects with a median age of 37 years.

The Kolmogoroff–Smirnoff–Lilliefors test was used to assess the normal distribution of the measured values. As almost all data were not normally distributed, nonparametric tests were used for all variables. In order to compare the baseline data of IG, CG and the German norm sample from 1994, the Kruskal–Wallis test was performed. Then, Conover–Iman comparisons with Bonferroni–Holm correction for multiple comparisons were performed. In addition, estimates of effects ($eta^2 = 0.01$ small effect, 0.06 moderate effect, 0.14 strong effect) were calculated. For the statistical analysis within each group, the Wilcoxon matched pairs test for ordinal and the McNemar test for nominal data were performed. As a secondary analysis, the measured values between the intervention and control group by the Wilcoxon–Mann–Whitney U test were compared. The Fisher test was used to analyze nominally scaled values. Moreover, the respective effect sizes were calculated for each test. In order to test gender specific differences, the Wilcoxon–Mann–Whitney U test was used to identify significant gender-specific differences in IG. All tests were performed two sided, using a significance level of $\alpha = 5\%$. The statistics program "IBM SPSS Statistics 26" was used for the statistical evaluation.

2.6. Ethics Approval

All participants provided written informed consent to take part in the study in advance. This study was approved by the ethics research committee of the Medical Faculty of the Landesärztekammer Baden-Württemberg, Germany (F-2017-073).

3. Results

3.1. Comparison of SF-36 Baseline Data

The comparison of the baseline SF-36 scores between IG, CG and the German norm sample from 1994 showed that CG had in each subscale a higher score than IG and, except for VT a higher score than the norm data sample (Figure 3). The Kruskal–Wallis test showed significant differences but, overall, small effect sizes between the baseline data in physical functioning ($p < 0.001$; $eta^2 = 0.037$), role limitations due to physical problems ($p = 0.047$; $eta^2 = 0.01$), bodily pain ($p < 0.01$; $eta^2 = 0.02$), general health perceptions ($p = 0.045$; $eta^2 = 0.01$) and physical health sum score ($p < 0.001$; $eta^2 = 0.014$). All other comparisons were not significant. The *p*-values for direct comparisons of the respective significant subscales are shown in Table 2.

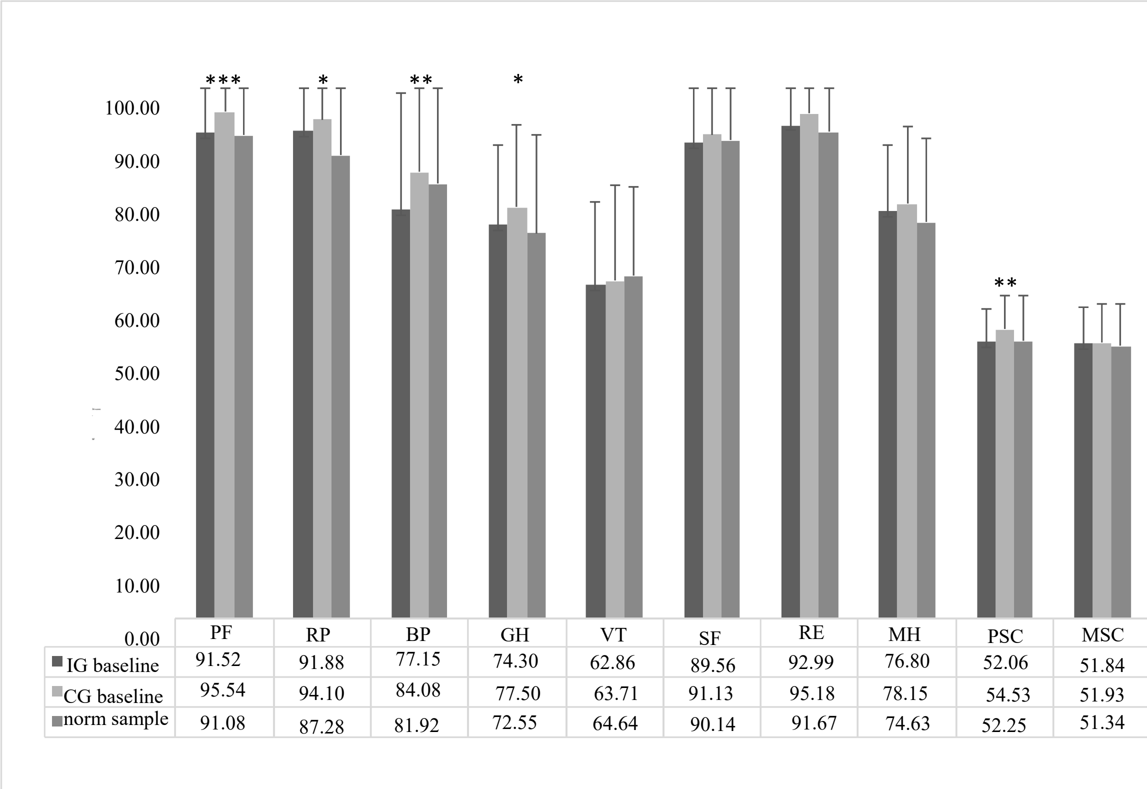


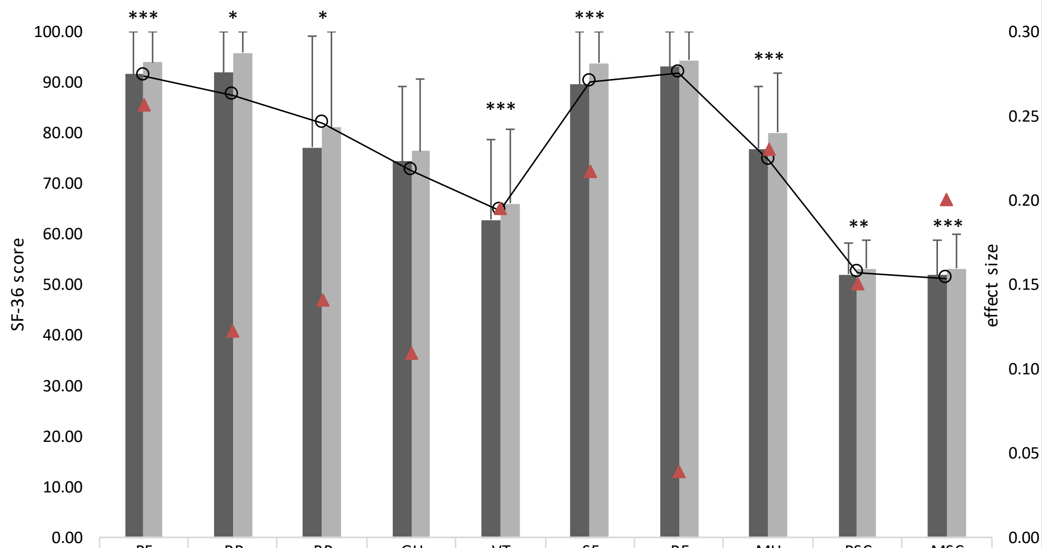
Figure 3. Baseline mean values of SF-36 outcomes for IG, CG and German norm data sample from 1994. Significant group differences are marked with asterisks. Subscales: physical functioning (PF), role limitations due to physical problems (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), mental health (MH) and physical and mental health sum scores (PSC and MSC, respectively). Significant differences are marked with asterisks ("*" = $p < 0.05$; "**" = $p < 0.01$; "***" = $p < 0.001$).

Table 2. *p*-Values for baseline data differences of IG, CG and the German norm data sample from 1994 for significant SF-36 outcomes PF, RP, BP, MH and PSC. Bonferroni–Holm correction for multiple comparisons has been applied.

	IG-CG	IG-Norm Sample	CG-Norm Sample
PF	< 0.001	0.005	0.001
RP	> 0.05	> 0.05	0.023
BP	0.049	< 0.000	> 0.05
GH	> 0.05	> 0.05	0.039
PSC	0.021	0.021	> 0.05

3.2. Examiation of the Effectiveness of the Intervention

The effectiveness of the intervention was examined by comparing the intervention group's pre–post results; significant improvements were observed in physical functioning ($p < 0.001$), role limitations due to physical problems ($p = 0.03$), bodily pain ($p = 0.013$), vitality ($p < 0.001$), social functioning ($p < 0.001$) and mental health ($p < 0.001$) (Figure 4). All subscales show improvements in the score compared to the baseline, although the overall effect sizes were rather small (0.04–0.26). While the baseline scores of the intervention group in the subscales bodily pain, vitality and social functioning were lower than those of the German norm sample, the intervention led to overall significant improvements in vitality and social functioning (Figure 4). Due to the significant increase in bodily pain, the IG is post-interventional within the range of the norm. Both the physical sum score and mental sum score of IG showed a significant improvement (PSC: $p = 0.009$; MSC: $p < 0.001$) compared to the baseline values (Figure 4). The outcomes of the subscales and sum scores of the baseline comparison within IG are summarized in Table 3.



	PF	RP	BP	GH	VT	SF	RE	MH	PSC	MSC
Intervention_pre	91.52	91.88	77.15	74.30	62.86	89.56	92.99	76.80	52.06	51.84
Intervention_post	93.97	95.89	81.13	76.47	66.10	93.75	94.30	80.01	53.22	53.22
norm sample	91.08	87.28	81.92	72.55	64.64	90.14	91.67	74.63	52.25	51.34
effect sizes	0.26	0.12	0.14	0.11	0.19	0.22	0.04	0.23	0.15	0.20

Figure 4. Mean values at baseline and after intervention for SF-36 outcomes of the intervention group. Mean values of the German norm sample of 1994 for SF-36 outcomes is also displayed. In addition, effect sizes are marked with red triangles. Significant pre–post differences are marked with asterisks. Subscales: physical functioning (PF), role limitations due to physical problems (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), mental health (MH) and physical and mental health sum scores (PSC and MSC, respectively). Significant differences are marked with asterisks (“*“ = $p < 0.05$;“**“ = $p < 0.01$;“ ***“ = $p < 0.001$).

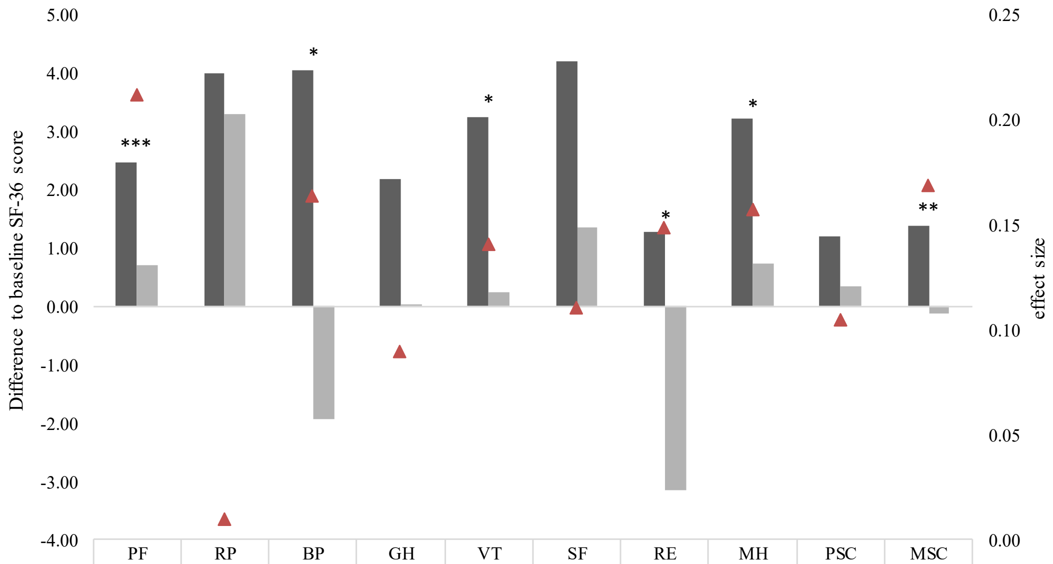
The control group showed no significant improvements compared to the baseline values. No directional change was descriptively discernible (Table 3).

The effects of the intervention control study are shown in Figure 5. Pre–post differences of IG and CG were compared. A significant difference can be observed for the subscales physical functioning ($p < 0.001$), bodily pain ($p = 0.010$), vitality ($p = 0.025$), role limitations due to emotional problems ($p = 0.018$) and mental health ($p = 0.012$). For the subscales role limitations due to physical problems, general health perceptions and social functioning no significant differences could be determined (Figure 5). In each SF-36 outcome, a greater improvement was observed in IG. The overall effect sizes are, analogous to baseline comparisons of IG, small. The comparison of the physical and the mental sum score show significant differences for MSC (PSC: $p = 0.103$; MSC: $p = 0.008$) in the control group (Figure 5). The effect sizes had rather small outcomes in all scales, in the range of 0.01 and 0.21 (Figure 5). Overall, outcomes of the subscales and sumscores between IG and CG are summarized in Table 3.

Table 3. SF-36 outcomes (mean, SD, *p*-value and effect size) are shown for IG (pre–post), CG (pre–post) and intervention control study (pre–post differences). Diff. means difference between post and baseline. Subscales: physical functioning (PF), role limitations due to physical problems (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), mental health (MH) and physical and mental health sum scores (PSC and MSC, respectively).

	Intervention Group				Control Group				Intervention–Control Study			
	Mean (SD)				Mean (SD)				Mean (SD)			
	Pre	Post	*p* Value [a]	Effect Size r [b]	Pre	Post	*p* Value [a]	Effect Size r [b]	diff. IG	diff. CG	*p* Value [c]	
PF	91.52 (10.38)	93.97 (10.17)	<0.001	0.26	96.51 (6.92)	97.22 (6.79)	0.056	0.19	2.45 (8.09)	0.70 (5.18)	<0.001	0.21
RP	91.88 (21.97)	95.89 (14.07)	0.030	0.12	94.15 (18.85)	97.19 (11.51)	0.053	0.01	3.98 (23.09)	3.28 (17.29)	>0.2	0.01
BP	77.15 (21.97)	81.13 (19.62)	0.013	0.14	83.68 (20.61)	81.76 (17.98)	>0.2	0.15	4.04 (18.69)	−1.93 (18.55)	0.01	0.16
GH	74.30 (14.88)	76.47 (14.04)	0.053	0.11	77.61 (15.35)	77.67 (13.41)	>0.2	0.08	2.17 (12.08)	0.02 (12.24)	0.154	0.09
VT	62.86 (15.77)	66.10 (14.67)	<0.001	0.19	63.74 (17.91)	63.96 (16.45)	>0.2	0.13	3.24 (11.88)	0.23 (13.94)	0.025	0.14
SF	89.56 (15.32)	93.75 (12.03)	<0.001	0.22	91.13 (14.70)	92.63 (13.08)	>0.2	0.10	4.19 (13.21)	1.34 (14.57)	0.080	0.11
RE	92.99 (19.26)	94.30 (19.25)	>0.2	0.04	95.44 (16.57)	92.28 (21.44)	0.090	0.13	1.27 (22.61)	−3.16 (19.49)	0.018	0.15
MH	76.80 (12.39)	80.01 (11.85)	<0.001	0.23	78.02 (14.34)	78.75 (13.27)	>0.2	0.14	3.21 (10.27)	0.72 (10.70)	0.012	0.16
PSC	52.06 (6.19)	53.22 (5.46)	0.009	0.15	54.11 (5.24)	54.42 (4.18)	>0.2	0.09	1.20 (5.24)	0.33 (4.64)	0.103	0.10
MSC	51.84 (6.84)	53.22 (6.62)	<0.001	0.20	52.00 (7.37)	51.75 (7.32)	>0.2	0.15	1.37 (5.86)	−0.13 (5.59)	0.008	0.17

[a] Wilcoxon test. [b] Effect size r after Rosenthal: 0.1 “small effect”, 0.3 “moderate effect”, 0.5 “strong effect”. [c] Wilcoxon–Mann–Whitney U test.



	PF	RP	BP	GH	VT	SF	RE	MH	PSC	MSC
■ Intervention group diff	2.45	3.98	4.04	2.17	3.24	4.19	1.27	3.21	1.20	1.37
■ Control group diff	0.70	3.28	-1.93	0.02	0.23	1.34	-3.16	0.72	0.33	-0.13
▲ effect size	0.21	0.01	0.16	0.09	0.14	0.11	0.15	0.16	0.10	0.17

Figure 5. Mean pre–post differences for IG and CG in SF-36 outcomes. Effect sizes are marked with red triangles. Significant pre–post differences are marked with asterisks. Subscales: physical functioning (PF), role limitations due to physical problems (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), mental health (MH) and physical and mental health sum scores (PSC and MSC, respectively). Significant differences are marked with asterisks ("*" = $p < 0.05$; "**" = $p < 0.01$; "***" = $p < 0.001$).

The participants of the intervention group felt significantly less irritable ($p = 0.031$), their energy faded significantly less fast ($p = 0.041$) and worries kept them up significantly less at night ($p = 0.039$).

3.3. Analysis for Gender Effects

The analysis for gender dependent differences showed no significant effects in any subscale of the SF-36 within IG.

4. Discussion

The main aim of this study was to measure the effectiveness of physical stretch training by means of a questionnaire on the health-related quality of life (QoL). The results of the intervention–control comparison relieved that significant improvements occurred in both areas due to the training. In three out of four psychological scores (*mental health* ($p = 0.012$), *role limitations due to emotional problems* ($p = 0.018$) and *vitality* ($p = 0.025$)) and two out of four physical scores (*physical functioning* ($p < 0.001$) and *bodily pain* ($p = 0.01$)) significant improvements were determined, thus indicating that stretch training may not only affect physical health parameters, but also mental health. These results confirm the initial hypothesis and are in line with studies reporting associations between physical activity and mental health and health-related QoL, respectively [18–21].

Looking at the cumulative scores, it is shown that only the *mental sum score* ($p = 0.008$) was significant improved while the *physical sum score* of SF-36 ($p = 0.103$) was not.

As well-known [41], the psychological well-being could be positively influenced, e.g., by less pain ($p = 0.009$) and a resulting improvement in social participation.

In addition, the intervention seems to encourage the subjects to influence their own well-being and to let physical complaints be controlled (RE ($p = 0.018$)). Furthermore, the reasons for the increased mental well-being may lie in an increased range of motion and thus reduced pain. This hypothesis can be supported by significant improvements in *bodily pain* and *physical functioning*, which can be confirmed by recent studies [42–44]. Goncalves and colleagues [43] found an inverse association between the frequency and severity of neck pain and the global health-related QoL. Other studies have shown that back pain and, in particular, chronic low back pain are associated with higher levels of subclinical anxiety and depression [42,44]. Stretching is one of the many methods that are recommended when suffering MSD, especially back pain [26]. In most cases, pain associated with MSD causes some degree of disability due to the limitation of range of motion [45,46]. Therefore, stretching may improve MSD-related pain by increasing the range of motion, improving blood circulation within the affected musculature, or by improving the nutrition of the intervertebral discs. Lawand et al. [47] reported of significant findings in SF-36 characteristics bodily pain, role limitations due to emotional problems, physical functioning, vitality, mental health, using the global postural reeducation stretching method in patients with chronic low back pain. In this study, 61 patients with chronic low back pain underwent a weekly 60-min stretching session for 12 months. These results confirm the results of the current study as exactly the same SF-36 characteristics showed significant improvements after a stretching period of 12 weeks, indicating that stretching training also leads to QoL benefits in office workers.

The study of Tunwattanapong et al. [15] is the only one, so far, that has evaluated health-related QoL outcomes in a stretching WHPP. They reported improvements in the health-related QoL (physical sum score—$p < 0.001$; mental sum score—$p = 0.084$). In contrast to the results of Tunwattanapong et al. [15], the present study showed significant improvements in the *mental sum score*, but not in the *physical sum score*, however, in two of the four measured dimensions. This could be explained by differences in the study protocol concerning exercise choice, intervention duration or sessions per week; the choice of exercises is distinctly different. While Tunwattanapong et al. [15] focused on exercises for the neck and shoulders, the present study mainly selected exercises for whole muscle chains; these are similar to yoga exercises. Hartfiel et al. [48] demonstrated that workplace-specific yoga training can contribute to the reduction of back pain and stress, as well as to the improvement of well-being. In the study of Tunwattanapong et al. [15], mainly mobilization exercises were used for the neck area, whereas in this study whole-body stretching exercises were used. However, both studies have shown a clear improvement in their respective scores, even if they were not significant, underlining the importance of stretching exercises on the health-related QoL. Furthermore, Tunwattanapong's study and the current study have shown that stretching in the operational setting appears to influence the health-related QoL.

A descriptive comparison of the absolute values between the two groups shows that, despite weaker values before the start of the study, the scores in all mental characteristics are after the intervention higher in the intervention group. This fact applies to all mental and not to any physical characteristics (Table 3). The heterogeneous composition of both groups provides one explanation. The intervention group is significantly older than the control group ($p < 0.010$), due to the fact that it was a waiting control group. This circumstance could explain the lower level of physical characteristics (Table 1). Despite the lower level of physical characteristics, the subjects of the intervention group achieved significant improvements in three out of four physical characteristics.

The analysis for gender specific differences suggests that gender does not appear to have any influence on the expression of SF-36 characteristics. According to this, women and men react similarly to stretching on both a physical and psychological level [49].

However, when interpreting the results, in view of the overall low effect sizes, it must be taken into account that the effects of stretching on characteristics of the health-related quality of life are supposedly on the threshold of clinical relevance despite significant differences. On the other hand, the effect size as a measure of changes in psychology is controversial and in a test with such good power as the SF-36 we could speak of moderate effects as early as 0.1 to 0.2. In particular, when the small group sizes are taken into account, the significance appears to be a good measure for the inclusion of the success of the intervention.

A random allocation would have led to a significant reduction in the number of participants and would have threatened the feasibility of the study, which is why a quasi-control group was chosen. Nevertheless, the lack of randomization must be taken into account when interpreting the results. For example, factors such as long holidays or absence, high workload or illness, which favor allocation to the control group, might influence the quality of life. Further possible uncontrolled sources that influence mental stabilization could be the individual attention of the trainers in the accompanied training units. Not least the mere possibility of participating in such a complex measure, in the sense of appreciation and experiencing a positive corporate culture, could also have had a positive effect on the result. Several studies have shown that especially active over passive pauses have positive effects on shoulder/neck pain [50–52]. It is noticeable that the reported frequency of breaks is much higher than in this study. It cannot be excluded that two breaks of 10 min per week will have an effect, but it is not to be expected.

Minor amendments had to be carried out on the method (Holzgreve et al. [35]): Two training sessions per week could not be adhered to due to holidays, meetings and illness, so that the study protocol had to be adapted (see Section 2.2). Further limitations can arise in the practical application if the training is not carried out with this high personnel expenditure, or that the extreme attention by sports scientists/physiotherapists during the training could also have contributed considerably to the effect. Since a successful implementation of a WHPP depends on the willingness of employees to participate, future studies should evaluate whether stretch training programs without such a high personnel expenditure achieve comparable results. Furthermore, future studies should observe whether a random assignment and equal pauses in the control group lead to similar results.

5. Conclusions

These results suggest that a stretching program performed for three months can improve the health-related QoL for office desk workers. The greatest changes were observed at the level of mental health. These findings indicate that a physical intervention program not only affects physical health parameters, but also mental health. The effects of such a WHPP go beyond the musculoskeletal system, indicating a promising measure to cover the current challenges of increasing competition and productivity demands in the workplace.

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Abbreviations

SD	standard deviation
QoL	quality of life
MSD	musculoskeletal disorders
WHPPs	workplace health promotion programs
IG	intervention group
CG	control group
PF	physical functioning
RP	role limitations due to physical problems
BP	bodily pain
GH	general health perceptions
VT	vitality

SF	social functioning
RE	role limitations due to emotional problems
MH	mental health
PSC	physical sum score
MSC	mental sum score

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4 Darstellung des eigenen Anteils

Publikation 1

Holzgreve F*	leistete wesentliche Beiträge zur Konzeption und Gestaltung des Manuskripts, leistete wesentliche Beiträge zum Aufbau des Messprotokolls und führte die Messungen vor Ort durch.
Maltry L*	leistete wesentliche Beiträge zur Konzeption und Gestaltung des Manuskripts, leistete wesentliche Beiträge zum Aufbau des Messprotokolls und führte die Messungen vor Ort durch.
Lampe J	leistete wesentliche Beiträge zur Konzeption und Gestaltung des Manuskripts, leistete wesentliche Beiträge zum Aufbau des Messprotokolls und führte die Messungen vor Ort durch.
Schmidt H	hat wesentliche Beiträge zu strukturellen und ausführungsspezifischen Aspekten des Studienprotokolls geleistet.
Bader A	hat wesentliche Beiträge zu strukturellen und ausführungsspezifischen Aspekten des Studienprotokolls geleistet.
Rey J	war an der statistischen Datenanalyse beteiligt.
Groneberg DA	hat wesentliche Beiträge zu strukturellen und ausführungsspezifischen Aspekten des Studienprotokolls geleistet.
van Mark A	leistete wesentliche Beiträge zum Aufbau des Messprotokolls.
Ohlendorf D	leistete wesentliche Beiträge zum Aufbau des Messprotokolls und las finale Korrektur.

*geteilte Erstautorschaft

Publikation 2

Holzgreve F	konzipierte und plante die Experimente und führte die Untersuchungen durch. Er schrieb das Manuskript mit Unterstützung von L.M., N.F., D.A.G., A.v.M. und D.O.
Maltry L	konzipierte und plante die Experimente und führte die Untersuchungen durch.
Hänel J	konzipierte und plante die Experimente und führte die Untersuchungen durch.
Schmidt H	konzipierte die ursprüngliche Idee und leitete u. A. das Projekt.
Bader A	konzipierte die ursprüngliche Idee und leitete u. A. das Projekt.
Frei M	konzipierte die ursprüngliche Idee und leitete u. A. das Projekt.
Filmann N	verifizierte die analytischen Methoden.
Groneberg DA	half bei der Überwachung des Projekts.
Ohlendorf D	konzipierte die ursprüngliche Idee. Konzipierte und plante die Untersuchungen und war mit der Überwachung des Projekts tätig.
van Mark A	konzipierte die ursprüngliche Idee. Konzipierte und plante die Untersuchungen und war mit der Überwachung des Projekts tätig.

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6 Schriftliche Erklärung

Ich erkläre ehrenwörtlich, dass ich die dem Fachbereich Medizin der Johann Wolfgang Goethe-Universität Frankfurt am Main zur Promotionsprüfung eingereichte Dissertation mit dem Titel

Effekte eines Dehntrainings auf die Lebensqualität von Büroangestellten im Rahmen der betrieblichen Gesundheitsförderung

am Institut für Arbeitsmedizin, Sozialmedizin und Umweltmedizin unter Betreuung und Anleitung von PD Dr. Dr. Daniela Ohlendorf ohne sonstige Hilfe selbst durchgeführt und bei der Abfassung der Arbeit keine anderen als die in der Dissertation angeführten Hilfsmittel benutzt habe. Darüber hinaus versichere ich, nicht die Hilfe einer kommerziellen Promotionsvermittlung in Anspruch genommen zu haben.
Ich habe bisher an keinem medizinischen Fachbereich einer in- oder ausländischen Universität ein Gesuch um Zulassung zur Promotion eingereicht. Die vorliegende Arbeit wurde bisher nicht als Dissertation eingereicht.

Vorliegende Ergebnisse der Arbeit wurden in folgendem Publikationsorgan veröffentlicht:

Holzgreve F, Maltry L, Lampe J, Schmidt H, Bader A, Rey J, Groneberg DA, van Mark A, Ohlendorf D. The office work and stretch training (OST) study: an individualized and standardized approach for reducing musculoskeletal disorders in office workers. *Journal of Occupational and Medical Toxicology* 2018;13(1):37. doi: 10.1186/s12995-018-0220-y.

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(Ort, Datum) (Unterschrift)