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PhD Thesis

Use of Digital Media for Remote Instruction in Exercise Sciences Education and Research

Lia Rigamonti

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Reviewer 1: Priv.-Doz. Dr. med. Klaus Bonaventura, M.A.

Reviewer 2: Prof. Dr. med. Kai Röcker

Reviewer 3: Prof. Dr. phil. Petra Grell

Supervisor 1: Priv.-Doz. Dr. David Alexander Back, MBA

Supervisor 2: Priv.-Doz. Dr. med. Klaus Bonaventura, M.A.

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Use of Digital Media for Remote Instruction in Exercise Sciences Education and Research

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by

Lia Rigamonti

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Affidavit according to the doctoral degree regulations (§ 4 (2), sentences No. 4 and 7) of the Faculty of Human Sciences, University of Potsdam:

I hereby declare that this thesis titled "Use of Digital Media for Remote Instruction in Exercise Sciences Education and Research", or part thereof, has not yet been submitted for a doctoral degree to this or any other institution in either identical or in similar form. The work presented in this thesis is the original work of the author. I did not receive any help or support from commercial consultants. All parts or single sentences, which have been taken analogously or literally from other sources, are identified as citations. Additionally, significant contributions from co-authors to the articles of this cumulative dissertation are acknowledged in the authors' contribution section.

Potsdam, 24.01.2022

Place, Date

Lia Rigamonti

Table of Contents

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Abstract

To grant high-quality evidence-based research in the field of exercise sciences, it is often necessary for various institutions to collaborate over longer distances and internationally. Here, not only with regard to the recent COVID-19-pandemic, digital means provide new options for remote scientific exchanges. This thesis is meant to analyse and test digital opportunities to support the dissemination of knowledge and instruction of investigators about defined examination protocols in an international multi-center context.

The project consisted of three studies. The first study, a questionnaire-based survey, aimed at learning about the opinions and preferences of digital learning or social media among students of sport science faculties in two universities each in Germany, the UK and Italy. Based on these findings, in a second study, an examination video of an ultrasound determination of the intima-media-thickness and diameter of an artery was distributed by a messenger app to doctors and nursing personnel as simulated investigators and efficacy of the test setting was analysed. Finally, a third study integrated the use of an augmented reality device for direct remote supervision of the same ultrasound examinations in a long-distance international setting with international experts from the fields of engineering and sports science and later remote supervision of augmented reality equipped physicians performing a given task.

The first study with 229 participating students revealed a high preference for YouTube to receive video-based knowledge as well as a preference for using WhatsApp and Facebook for peer-to-peer contacts for learning purposes and to exchange and discuss knowledge. In the second study, video-based instructions send by WhatsApp messenger showed high approval of the setup in both study groups, one with doctors familiar with the use of ultrasound technology as well as one with nursing staff who were not familiar with the device, with similar results in overall time of performance and the measurements of the femoral arteries. In the third and final study, experts from different continents were connected remotely to the examination site via an augmented reality device with good transmission quality. The remote supervision to doctors´ examination produced a good interrater correlation. Experiences with the augmented reality-based setting were rated as highly positive by the participants. Potential benefits of this technique were seen in the fields of education, movement analysis, and supervision.

Concluding, the findings of this thesis were able to suggest modern and addressee-centred digital solutions to enhance the understanding of given examinations techniques of potential investigators in exercise science research projects. Head-mounted augmented reality devices have a special value and may be recommended for collaborative research projects with physical examination–based research questions. While the established setting should be further investigated in prospective clinical studies, digital competencies of future researchers should already be enhanced during the early stages of their education.

Zusammenfassung

Für eine qualitativ hochwertige, evidenzbasierte Forschung im Bereich der Bewegungswissenschaften ist es oft notwendig, dass verschiedene Einrichtungen über größere Entfernungen und auch international zusammenarbeiten. Nicht nur im Hinblick auf die aktuelle COVID-19-Pandemie können hier digitale Mittel neue Möglichkeiten des wissenschaftlichen Austauschs ermöglichen. In dieser Arbeit sollten digitale Möglichkeiten analysiert und getestet werden, wie eine Wissensverbreitung und Instruktion von Untersucherinnen und Untersuchern über definierte Protokolle in einem internationalen multizentrischen Kontext erfolgen könnte.

Das Projekt bestand aus drei Studien. Die erste Studie, eine Fragebogen-basierte Umfrage, zielte darauf ab, die Meinungen und Präferenzen von Studierenden sportwissenschaftlicher Fakultäten an je zwei Universitäten in Deutschland, Großbritannien und Italien in Bezug auf digitales Lernen oder soziale Medien zu erfahren. Darauf aufbauend wurde in einer zweiten Studie ein Untersuchungsvideo einer Ultraschallbestimmung der Intima-Media-Dicke und des Durchmessers einer Arterie mittels einer Messenger-App an ärztliches und Pflegepersonal als simulierte Untersucherinnen und Untersucher versendet und die Wirksamkeit des Testsettings analysiert. Schließlich wurde in einer dritten Studie die Verwendung eines Augmented-Reality Geräts zur direkten Fernbegleitung der gleichen Ultraschalluntersuchungen in einem Ansatz mit internationalen Experten aus den Bereichen Ingenieur- und Sportwissenschaften und zur Fernbegleitung von Ärztinnen und Ärzten bei einer Untersuchung integriert.

Die erste Studie mit 229 teilnehmenden Studierenden ergab eine hohe Präferenz für YouTube, um videobasiertes Wissen zu erhalten, sowie eine Präferenz für die Nutzung

von WhatsApp und Facebook für Kontakte unter Studierenden für Lernzwecke und zum Wissensaustausch. In der zweiten Studie zeigten videobasierte Anleitungen, die per WhatsApp-Messenger verschickt wurden, eine hohe Zustimmung in beiden Studiengruppen, sowohl bei Ärztinnen und Ärzten, die mit der Anwendung der Ultraschalltechnologie vertraut waren, als auch bei Pflegepersonal, das mit dem Gerät nicht vertraut war, mit ähnlichen Ergebnissen bei der Gesamtdurchführungszeit und den Messungen der Femoralarterien. In der dritten und letzten Studie wurden Experten aus verschiedenen Kontinenten über ein Augmented-Reality Gerät mit guter Übertragungsqualität mit dem Untersuchungsort verbunden. Die Begleitung der ärztlichen Untersuchung über größere Entfernungen ergab eine gute Interrater-Korrelation. Die Erfahrungen mit dem Augmented Reality-basierten Setting wurden von Teilnehmerinnen und Teilnehmern als sehr positiv bewertet. Potenzielle Vorteile dieser Technik wurden in den Bereichen Ausbildung, Bewegungsanalyse und Supervision gesehen.

Zusammenfassend konnten die Ergebnisse dieser Arbeit moderne und adressatenorientierte digitale Lösungen vorschlagen, um das Verständnis für vorgegebene Untersuchungstechniken von potenziellen Untersuchenden in bewegungswissenschaftlichen Forschungsprojekten zu verbessern. Kopfgetragene Augmented-Reality Geräte können für multizentrische Forschungsprojekte mit untersuchungsbasierten Forschungsfragen empfohlen werden. Während das etablierte Setting in prospektiven klinischen Studien weiter untersucht werden sollte, sollten zudem auch digitale Kompetenzen angehender Wissenschaftlerinnen und Wissenschaftler bereits in frühen Phasen ihrer Ausbildung gefördert werden.

1. Introduction

“COVID-19 and digitalization: The great acceleration” (1)

This article from October 2020 was one of many scientific publications focusing on the changes and new opportunities which influence and enrich various fields of daily life at the onset and with the global spread of the Sars-CoV-2 (COVID-19) pandemic. As in other areas, inventions and digital adaptations in sports, exercise sciences or sports medicine were additionally pushed forward by the pandemic in the recent time (2).

As topic with a similar comprehensive impact on peoples´ daily life worldwide, digitalization is closely linked to modern sports sciences. Research in the field of sports medicine and clinical exercise sciences offers great opportunities not only to improve the performance of lay and professional athletes (3), but also to enhance the knowledge about diseases (4-6) – and is gaining global importance. The consequences of digital innovations on people´s professional and private life, politics, economics or the health systems can nowadays be regarded as “digital transformation” of the life we used to know (7). While the first changes, dealing with the integration of software and internet into processes, were often addressed with industry or medicine “2.0” (8) within a few years a new term developed. First the industry, then also health sciences, increasingly used the term “4.0” to describe the interaction of technical systems using among others large amounts of data and artificial network solutions (9).

In the flow of digital innovations, not only new products and programs were developed, but those developments also led to completely new approaches for problem solving and consequently led to a change of structures to such a great extent that these are referred to as disruptive technologies (10). Already in the near future, a substantial socio-economic impact can be expected through the use of digital features in medical prevention, therapy and rehabilitation (11). In this context, the demographic changes towards an elderly population have to be taken into consideration as well (12, 13).

Many of the new digital features are already being used in sports and exercise sciences (14). There are various aspects where the field of clinical exercise science could profit from new forms of communications and distribution of knowledge by the use of modern digital media – also with regard to multi-center research projects to foster the gain of knowledge about relevant diseases. Thus, a new era of interactions between physicians and patients, but also interdisciplinary and international collaborations in sport science can be anticipated (15).

Likewise, these international and interdisciplinary connections of sport and exercise sciences benefit many other medical disciplines (e.g. orthopaedics or cardiology) as well as other health professions (16). Due to the impact of sports and exercise programs not only in terms of diagnostics and therapies of athletes and patients today, but in terms of prevention and rehabilitation of various illnesses in populations of the future, the field of sport and exercise sciences has and will have a relevant socio-economic impact (12, 17).

Communication and interaction are of the utmost importance for all professionals working in a team environment in the field of sports and medicine whether in practical work or research. The travel and contact restrictions during the recent COVID-19 pandemic have brought to light just how challenging and critical it can be to set up and maintain meetings, trainings or coordination of practical performances for scientists or clinicians over long distances (18). Collaboration is important for scientific exchange, to increase numbers of study participants or to establish standardized protocols.

2. Literature review

2.1. Multi-center and (inter)national collaborations in sport science and medicine

Collaborative research strategies are in most cases the decisive basis to exchange expertise of different specialist institutions and persons and to gain scientific results with highest evidence (19). This has consecutively an enormous impact on diagnostic, therapeutic and preventive approaches. In sports sciences, such approaches, for example, have enabled randomized controlled trials (RCT) giving rise to new perceptions regarding the prevention of sport-related injuries in professional athletes (20). In addition, interventional multi-center studies focusing on changing normal people's movement behavior of a period of one year could have been performed (21). Large international RCTs also have the potential to provide treatment recommendations for physical therapies in medical patients with certain diseases (e.g., stroke) even with effects on existing guidelines (22).

The benefits do not just include an exchange of experiences or established techniques (18). Another advantage may be that the number of participants in studies can be increased, which in turn strengthens the validity of the results gained (23). These approaches created the basis for many medical high evidence studies, whose evidence level set the stock for the adoption or creation of new treatment methods and guidelines in many countries (24). Challenges can be found in establishing common research and study protocols and keeping and controlling the quality of adherence to them among all participating scientists (25).

In sports, exchanges and assimilation of techniques and rules are often internationally organized and standardized (26). Depending on the field of sport, the number of athletes can vary and thus also the number of potential subjects or patients that can be included for sport-specific examinations by a single exercise and sport science institutes can be limited (27, 28). Thus, it seems recommendable to encourage the collaborations of exercise science institutes and researchers worldwide for investigations with common research questions especially in mid- and small-sized populations of athletes. A promising basis not only for scientific exchanges, but also sharing of data, knowledge and skills in general can be established by means of modern digital media (29, 30).

2.2. Digitalization in sports science and medicine

Digitalization can help to improve interdisciplinary and international collaborations in health care and especially also in exercise sciences and, thus, can support the health of individual athletes, patients or even whole populations (16). There are various technological fields, which can be highlighted in this context. In a recent publication, the following fields were identified and described (14):

Mobile Applications in Exercise Health and Sport Medicine are highly popular, but differ also strongly in their intended purpose and quality. Topics can be data recordings and tracking, promotion of behavioral changes, social interaction, sleep monitoring, or rehabilitation programs (31-34). Already the quantification and selection of apps can be difficult: While 97,182 „Sport“-related apps could be identified in Apple’s U.S. App Store in April 2021 and 51,964 in Google´s Play Store, this search still does not cover apps available in categories like „Medicine“ or „Health&Fitness“ (35, 36). Only few scientific evidence can be found for contents, functionalities or long-term health benefits of most apps (37, 38). In order to help athletes, patients and healthcare providers identify useful and reliable apps, there is a need for defined regulations (e.g., FDA-approval, CE-certification) or quality seals (39).

Closely linked to the area of mobile applications are “wearables” and smart devices which together are expected to increase in the global market from a volume of US$ 16.8 billion in 2019 to US$ 21.4 billion by 2024 (40). In sports, clothes with digital sensors can help trainers to monitor their athletes for signs of fatigue or overexertion and to detect, e.g., heart pathologies like arrhythmias in patients (41, 42). Finally, intelligent functions of machines in a rehabilitative setting like exoskeletons or antigravity treadmills can support patients´ convalescence (43, 44).

Looking at direct digital patient-doctor interaction, video-based telemedicine has become a relevant form of contact in the recent years with high acceptance rates among patients and doctors (45). Advantages comprise of a reduction of wait times and travel costs for patients and the health system (46). Especially in amateur sports, they have also been described as useful tools in the primary assessment of injuries (47). Beyond this, athletes can be digitally accompanied by their familiar doctors all around the world (48).

Another rather new and interesting topic is the use of augmented reality or virtual reality (VR) in sports sciences. Based on special screens or even glasses, augmented reality is often referred to as integration of three-dimensional virtual objects into the real vision environment of the users, while virtual reality offers users an imitated true virtual surrounding (49). In the context of this thesis, augmented reality can be used for remote support in examinations or therapies (50) (Figure 1). Virtual reality or exergaming have already been described for motivating users in sports and rehabilitation (51, 52). Finally, the broad field of big data, artificial intelligence and system interoperability can be regarded as great potential for the future in sports and health sciences. Since sports sciences and sport medicine are one of the world´s largest sources of health-related digital data (53) and can thus support the creation of guidelines, training, prevention or treatments (54).

Fig. 1: Example of the use of an augmented reality device (Hololens 2, Microsoft Corp.) with remote supervision during a mobile ultrasound measurement (55).

Artificial intelligence-based tools can be used already today for data analysis as well as primary assessment of patients´ complaints (56). In many settings of analyzing athletes´ performance or medical tracking and surveillance, system interoperability will be decisive for connecting medical records, smart devices and therapies or exercise approaches (57). Further important topics in the field of digitalization are educational aspects and social media use, which will be covered in the context of the next chapter.

2.3. E-learning and social media use in human science education

Internet-connected digitally supported learning and teaching can look back on almost two decades of experience. This way of education, often referred to as electronic learning or e-Learning (58) has become an inherent part of the academic world (59, 60) used either solely or in connection with face-to-face teachings as blended learning (61, 62). The various means of teaching encompass videos, podcasts, interactive texts, virtual patients (63, 64), but lately also serious games (65). As a more futuristic field with still unexhausted potential, AR and VR devices and applications can be used in the field of education, training and international research and clinical collaborations (66). VR devices have been proven to be beneficial in motivating patients and lay people for indicated movement patterns (67). AR devices enable the exchange of information with holographic imaging with the chance of remote support in case of technical questions (68). This provides the possibility to project lines or display symbols, like arrows, into the field of vision of the investigators, but also to display drawings, pictures or videos to support the understanding and, thus, the performance of the person wearing the AR device (69).

Various studies have shown a high appreciation of digital teaching methods by students (64, 70, 71). In sports sciences, there have been different reports about the use of e-learning methods to improve people’s understanding of techniques and in medical contexts about sport-related pathologies or diseases (62, 72, 73). Here, digital platforms enabled a better distribution of their contents (74). In the vast field of exercise science related research, the practice of movements (75) but also therapeutic solutions (76) have incorporated the use of digital media. With the rise of smartphones, the use of mobile applications has increased in the areas of sport and fitness. Institutions like the American College of Sports Medicine have even created their own guidelines on how to handle these digital offerings (77).

In this context, one digital form of communication has taken a strong foothold in everyday life over the last decade: Social Media. Following their widespread use in daily life, different social media were soon appreciated by students as part of learning scenarios (30) and used by researchers (29) and clinicians for work purposes and the exchange of ideas and information (78). Especially when dealing with clinical communication, there are examples of the transmission of pictures like radiological images (79) or ultrasound results

(80), but also cases, where techniques were being taught (81). In addition, social media and social networks set the basis for the popularity of various sports due to their massive media presence (82, 83). Both patients and medical facilities use social media in the context of communicating about sport-related injuries (84). Data show that athletes perceive them as a means to obtaining medical information about discomforts or training (85). In all these aspects, legal issues and questions of data protection and ethics always have to be addressed. Here, different legal frameworks and settings were created in recent years to protect not only the personal data of patients, but also to regulate the handling, storing and processing of data (86). This follows various ethical questions starting with the ownership of data received from individuals up to the extend as to how far intelligent digital algorithms may influence the decision making process (87).

2.4. Game changer COVID19

Within only a few months, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or also coronavirus disease 2019 (COVID-19) pandemic has changed the personal, cultural and professional life of almost every person around the globe (88). After identification of the virus in the city of Wuhan, China, in December 2019 (89), COVID-19 was declared as pandemic by the World Health Organization (WHO) on 11 March 2020 (90). For more than one year, due to a lack of existing vaccinations or other sufficient curative medical treatment options, societies worldwide had to face reoccurring quickly raising infection rates with a vast amount of severely sick people, which even led to scenarios as triage situations for intensive care unit beds, known before only from catastrophic and combat medicine surroundings (91). Hence, from about March 2020 onwards, Europe and many other countries in the world started into a nationally varying series of so-called “lockdowns” by limiting people´s contacts and freedom of movement to prevent viral disease from spreading further (92). Established ways of communication, planning and acting in sports, exercise sciences and medicine were rapidly adapted to the new regulations with strict restrictions of interpersonal contacts (93).

Like in other areas of private and professional life, the scientific community had to follow this new set of regulations. Digital conferences became a normality and concentration on theoretical work and planning or preparation of projects gained more importance (94). However, drawbacks of this situation became strongly visible. Different medical experts reported about a noticeable decline of research activities due to the necessary contact and working restrictions in basic research (95). Especially clinically focused projects suffered from the restrictions in terms of recruiting human subjects as well as, for example, from the delay of data entry into clinical trial databases (96).

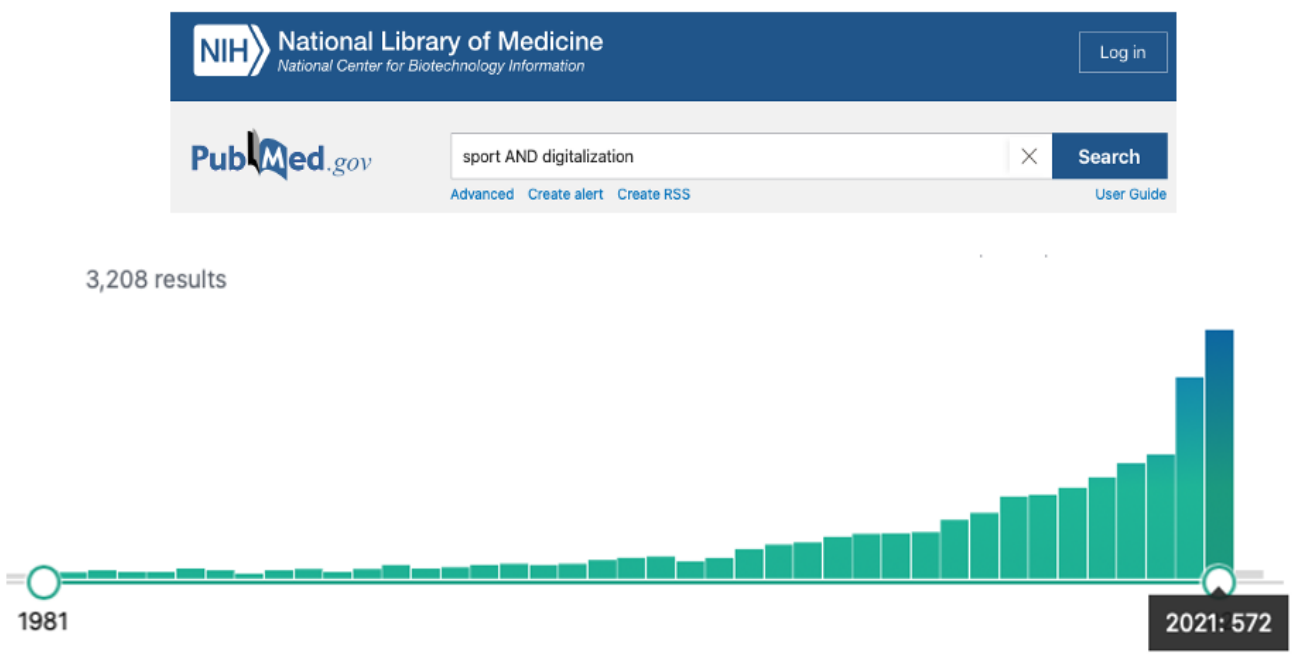

Fig. 2: Development of scientific publication activities in the field of sport and digitalization as found on “https://pubmed.ncbi.nlm.nih.gov” (search performed on 17th December 2021, mesh terms “sport AND digitalization” from 1981 to 2021)

While many important approaches towards the use of digital means in sports sciences and medicine have already been made in the last decades in education, training, diagnostics, therapies, and legal and ethical fields, the Covid-19 pandemic has given a strong push towards change. The importance and potential of digitalization were made obvious and intensively used with the implementation of travel and contact restrictions (1). Also, in the field of science a significant increase of publications in the context of sport and digitalization could be noted (see fig. 1, showing a search on https://pubmed.ncbi.nlm.nih.gov on 17th December 2021).

2.5. Vascular changes and their examination

There are many connections which support the transfer of scientific and research findings into practical clinical applications in fields of prevention, diagnostics and therapies between health sciences, sport medicine and exercise sciences. In this context, the examination of pathologies in young or elder sportive adults can help to better understand individual intrinsic predispositions or extrinsic influences for diseases, but can also help in learning more about certain pathologies (97).

Here, one field of interest are cardiovascular diseases. Various publications have already covered the impact of specific sport and exercise training on the modification of vascular structures (98, 99). Reported reactions, e.g., in athletes' arteries are a widening of the arterial diameter or a decreasing intima media thickness (99-101). Such observations can be useful in understanding underlying pathologies, since this disease cluster is a relevant burden for people worldwide and has been increasing in recent years (102). At a range of 11% (103) to 20% (104), the elderly are more prone to the disease and the underlying structural vessel affections can cause acute coronary syndromes, cerebrovascular diseases or the peripheral arterial disease (105). In peripheral arterial diseases, claudication symptoms (106) can lead to the need of clinical interventions or surgical treatments up to amputations (107). These treatments and the overall course of therapy are costly for the social services (107, 108).

The pathologies in affected arteries are often connected to hypertrophic changes of the arterial walls (109, 110). Here, regarding the identification of pathologic changes in arteries, the intima-media thickness (IMT) has been identified as good predictor of cardiovascular events (111, 112). Focusing on established ways of diagnosing the vascular status of a patient by imaging, the gold standard especially in the analysis of atherosclerotic diseases is still the ultrasound as most common and reliable non-invasive tool (113), alongside the more complex radiological imaging like computer tomography (CT) with contrast medium or the magnetic resonance imaging (MRI). For many decades, ultrasound has been utilized increasingly for medical purposes (114). It nowadays encompasses a broad field of indications especially in the diagnostic field (115), but also as supportive means in interventions (116) and is used in nearly every medical discipline, in particular in the different areas of exercise sciences (117). Other than in radiographic imaging, since the ultrasound transducer has to be held and guided by the examiner, the image quality is highly dependent on the individual examiner (118). To address this and to objectify examination results by ultrasound, different scoring systems have been invented and introduced for different indications, such as assessment of dysplasia in the hips of newborn (118) or in the field of obstetrics and gynecology (119).

3. Research objectives

Focusing on the necessity and the benefits of inter-institutional and international collaborations in research in clinical exercise sciences, this work is meant to explore and test digital opportunities to support the dissemination of knowledge and instruction of researchers about defined research protocols and examination methods. This topic has not received much attention in exercise sciences and other health disciplines. The **main hypothesis of this work** was that it is possible to establish a model for an international multi-center study in clinical exercise sciences with social media as e-learning distributor for an examination technique among young peer scientists, using an ultrasound-based arterial measurement setting. For this purpose, three consecutive studies were designed:

In a **first step**, a study should focus on gathering opinions and preferences of modern students in the field of sports and exercise sciences concerning the use of e-learning and social media (Facebook, Google+, Instagram, LinkedIn, Skype, Twitter, WhatsApp, YouTube). Students should be addressed since the undergraduates of today will be the young research generation of tomorrow and it is paramount to choose the right digital tools which would meet their habits and needs. This first study will be established on a questionnaire-based survey. To avoid the bias of reporting only the opinions of students at one single university and in one country, two universities in Germany, United Kingdom (UK) and Italy each should be selected to determine potential national differences in preferences of digital learning or communication tools. Identification of the most preferred e-learning tool and social media application would form the basis for the design and outcome of the following two studies.

In a **second study**, an e-learning tool distributed by a social media application (both identified before), will be tested for its effectiveness in helping with the instruction of investigators on a certain examination technique. The chosen procedure is an ultrasound vascular measurement to determine the intima-media-thickness and diameter of the femoral arteries. The idea behind this is that such a technique can be useful in the context of long-distance or multi-center collaboration projects especially in sports medicine and exercise sciences, when investigators with different levels of experience shall get to know a certain methodology and have to get familiar with the practical procedures of an examination or diagnostic process. Data will include examination results, time of performance, score-based performance rating, as well as evaluation of participants´ experience with social media and their approval of the methodology. To compare the effect on differently experienced individuals – as simulation of research situations, with differently trained investigators in a multi-center study setting – doctors and nursing personnel shall be chosen with differing levels of familiarity with the applied technique.

The **last project** shall finally focus on the effectiveness to use an augmented reality device for remote supervision of exercise science examinations based on the experiences and examination protocol of the second approach. The context are long-distance or multi-center health science collaboration projects, where investigators are challenged to overcome distances and to meet the need for direct interaction during the defined procedures. In a first part, international experts from the fields of engineering and sports science shall be remotely connected to a study setting via the augmented reality device while internet connection speed as well as a structured interview shall be recorded. In a second part, remote supervisors shall evaluate physicians performing an examination while wearing the augmented reality device. Gained data shall include the participants´ evaluation, opinion of the setting and the tools as well as their view in regards to the general feasibility of the chosen method. The relevance of the last part of this PhD thesis was dramatically amplified by the COVID-19 pandemic. The pandemic regulations with travel restrictions and the need to cut down personal human contacts led to slight adjustments of the study, so that all real examinations on a human subject were performed in the region of Berlin, Germany.

The three studies presented in this dissertation manuscript have been published in peer-reviewed journals (chapters 4.1, 4.2, and 4.3). Details about the journals, each study's design, the number of participants and the methods used in each of the studies are shown in table 1.

Table 1: Studies of the presented PhD thesis

Study	Journal	Design	Participants	Measures	Chapter
1	*Health Promot Int.* (peer-reviewed)	International multi-center survey	229 Students	Questionnaire-based survey, descriptive data analysis	4.1
2	*Int J Sports Med* (peer-reviewed)	Comparative cohort study	10 doctors 10 nurses	Time of performance, measurement data, score achievements, user evaluation	4.2
3	*J Med Internet Res* (peer-reviewed)	Observational study	8 engineers / sport scientists 2 supervisors 8 doctors	Feasibility of distance data transmission with augmented reality technique, user evaluation	4.3

The thesis´ articles can be found below, each containing an introduction, a description of the methods used, the result, the discussion and the literature references.

4. Studies

4.1. Study 1

Social media and e-learning use among European exercise science students

Rigamonti L[1], Dolci A[2], Galetta F[3], Stefanelli C[4], Hughes M[5], Bartsch M[6], Seidelmeier I [7], Bonaventura K [1,8], Back DA [9,10]

1 Outpatient Clinic, Sports Medicine & Sports Orthopaedics, University of Potsdam, Potsdam, Germany
2 Faculty of Science and Technology, University of Westminster, London, United Kingdom
3 Department of Clinical and Experimental Medicine, University of Pisa, Pisa, Italy
4 Department for Life Quality Studies, University of Bologna, Rimini, Italy
5 Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK, United Kingdom
6 Department of Sport Medicine, Charité – Universitätsmedizin Berlin, Berlin
7 Department for Sport Science, Bundeswehr University Munich, Munich, Germany;
8 Department of Internal Medicine/Cardiology and Angiology, Ernst-von-Bergmann Clinic, Potsdam, Germany
9 Bundeswehr Hospital Berlin, Clinic of Traumatology and Orthopedics, Berlin, Germany
10 Dieter Scheffner Center for Medical Teaching and Educational Research, Charité – Universitätsmedizin Berlin, Berlin, Germany

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4.1.1. Abstract

Introduction: With the rise of digital technologies, electronic learning and communication tools are becoming a firm part of academia to promote knowledge in health sciences. This study sought to analyse the attitude of students regarding social media and digital learning for study purposes in sport and exercise science.

Materials and Methods: A survey was carried out with a questionnaire (20 main items) in six sport science faculties, equally spread across Germany (G), Italy (I) and the United Kingdom (UK) between February and October 2017. The focus areas were students´ usage of social media (Facebook, Google+, Instagram, LinkedIn, Skype, Twitter, WhatsApp, YouTube) for academic purposes and their use of e-learning. Data were analysed by quantitative and qualitative methods.

Results: 229 students participated in the study (G: 68, I: 121, UK: 40). While YouTube was mostly used for receiving knowledge, WhatsApp and Facebook showed additional preferences for peer contacts for learning purposes and knowledge discussions. Preferred online data sources were PubMed (77%), free access journals (67%), YouTube (66%) and Wikipedia (63%). Often used digital learning materials were own universities´ PowerPoints (77%), scripts (59%) and scientific articles (53%). However, some preferences showed national differences.

Discussion: The evaluated participants showed an overall high use of social media and e-learning tools for their studies. Students would like more digital learning sources made available to them by their institutions. However, some differences in preferences of digital learning or communication tools may exist and this should be considered for international approaches to promote health knowledge among students.

Keywords: Sport, university students, evaluation, education, health

4.1.2. Introduction

University education in the health sciences provides research and innovations which contribute to development of technologies and exercise training methods as well as medical diagnostics and therapies. Especially with the rise of the internet, digitally supported media in teaching and learning (e-learning) (Ruiz, Mintzer, & Leipzig, 2006) have already taken a firm place in many fields of academia (Isidori, Frias, & Echazarreta, 2015; Liu, Huang, & Hsu, 2015), mostly as supplement to face-to-face teaching as blended learning (Ruiz, et al., 2006; Vernadakis, Avgerinos, Zetou, Giannousi, & Kioumourtzoglou, 2006). As a modern mode of education, e-learning is highly appreciated by students across all academic fields (Dahlstrom and Jaqueline, 2014). Also for health sciences, e-learning has proved to be an important support to mediate knowledge about specific pathologies or diseases (Back et al., 2017) and also physical training techniques (Hayes and Silberman, 2007; Vernadakis, et al., 2006), based, for instance, on online learning management platforms for a better provision and distribution of digital tools (Huang, Chiu, Chin, Hsin, & Yu, 2010). Additionally, another form of digital tools has also entered the academic world in recent years, with the use of social media for educational purposes. There is a large variety of studies reporting on the use of tools among students and teachers for communication and teaching purposes by integrating these tools in different course settings of medical and sport sciences (Awan, Awan, Alshawwa, Tekian, & Park, 2018; Cole et al., 2017; Kinchin and Bryant, 2015; Pilieci, Salim, Heffernan, Itani, & Khadaroo, 2018). Other data show that social media are well accepted and used for work purposes also among well-established researchers (Van Noorden, 2014).

Digital media currently enables academic institutions to share their knowledge with teachers and students worldwide, as, for example, with massive open online courses

(MOOCs), whose use is also reported for the field of sport and exercise medicine education (Griffin and Shrier, 2016).

The sport and health sciences span a range of subjects in research and education involving general physiological backgrounds (Halperin, 2018), preventive health measures (Elliot and Hamlin, 2018) or also particular clinical views on relevant musculoskeletal and cardiovascular diseases (Baldwin, Briggs, Bagg, & Larmer, 2017; Pearson and Smart, 2017), which all have an impact on various areas that are central to modern societies. Consequently, they may profit from new forms of communications and distribution of knowledge by the use of modern digital media. Knowing about the preferences of social media and digital learning can be valuable when planning to promote international educational courses in health sciences or also academic collaborations as preferences of use of certain digital tools may differ between nations and cultures (Saw, Abbott, Donaghey, & McDonald, 2013).

As no scientific publications could be found in this context, this orienting study aimed to identify attitudes and preferences of students in the field of sports and exercise science concerning the use of e-learning and social media in universities in different European countries.

4.1.3. Methods

A multi-center observational study entitled "Survey of Social Media and e-Learning in Sport Science and Sport Medicine" was carried out in each two faculties of sport, health and exercise sciences of universities in Germany (G), Italy (I) and the United Kingdom (UK) from February till October 2017.

Development of the questionnaires

Focus content areas for the questionnaire were identified by a search on PubMed and MEDLINE. Guidelines for the improvement of the quality of online surveys (Eysenbach, 2004) and empirical social research methods (Schnell, Hill, & Esser, 2008) were considered. The preliminary questionnaire was sent to individual experts in the field of sports science as members of the addressed international faculties for a peer review control as well as to single chosen students for validation of the questions. Their suggestions were integrated into the final version of the questionnaire, which was translated into English (supplement 1), German and Italian by native speakers, followed by a content control by the authors.

The final 20 questions were divided into 3 main groups that addressed the following areas of interest:

1. Sociodemographic data (gender, age, university, semester) (6 questions)
2. Use of social media for their studies (focus on 8 common applications of social media with each 9 optional responses addressing their use for receiving or sharing data with other students or teachers, within or beyond universities´ circles)
3. Use of e-learning tools for their studies (focus on the use of online sources for gaining scientific information, digital learning tools and their embedding into studies) (6 question fields).

Study design

Before the beginning of the study, formal approval was gained from the responsible data protection office and ethics committee of the University of Potsdam (No: 35/2016). The study population consisted of sport and exercise sciences students enlisted at the addressed faculties. Anonymous participation was granted for all students. The questionnaire was designed by the internet-based survey tool SurveyMonkey® (SurveyMonkey Inc., Oregon, USA), but delivered to the participants as hard copies to enable a standardized distribution to students in all participating institutions regardless from their individual computer equipment.

Contact persons at the single institutions invited students for their voluntary participation by direct approach in the course of their classes. Participants were informed by an integrated preface about the contents of the survey, anonymity and voluntariness of participation. Informed consent was given by voluntary participation. The collected data was entered into an Excel® document (Microsoft Corp., Redmond, WA, USA) for descriptive analysis.

Data analysis

A quantitative analysis of the data was performed by descriptive statistical means using Excel (Version 2016, Microsoft Inc., Redmond, WA, USA). For each answer, the overall average and the country specific results were determined. When numbers were additionally calculated in percent (%), they were always put in relation to the total or country specific numbers of included participants. Two reviewers independently analysed individual free-text answers within the questionnaires for repetitive sequences, which were then summarized. A systematic rule guided qualitative text analysis was applied using techniques of qualitative content analysis according to Mayring (Mayring, 2000).

4.1.4. Results

A total of 229 students participated in the survey (G: n = 68, I: n = 121, UK: n = 40). There were 146 male (G: n = 43, I: n = 87, UK: n = 16) and 83 female (G: n = 25, I: n = 34, UK: n = 24) students. The participants were on the average 23.1 (G), 21.8 (I) or 24.7 (UK) years old.

Use of social media in studies

The conditions and intentions of use of the social media tools for study purposes are shown in figure 1.

Use of digital learning in studies

Asked, how often they used e-Learning contents (defined as any kind of online derived learning/teaching/knowledge materials) for their studies (n = 227 answering participants, n = 2 abstentions), 54 (24%) students stated more than once a week (G: n = 19, 28%; I: n = 20, 17%; UK: n = 15, 38%).

62 (27%) participants used them at least once a week (G: n = 24, 36%; I: n = 30, 25%; UK: n = 8, 20%), 57 (25%) less than one a week but at least once a month (G: n = 15, 22%; I: n = 34, 28% ; UK: n = 8, 20%), and 27 (12%) less than once a month (G: n = 6, 9%; I: n = 15, 13% ; UK: n = 6, 15%). 27 (12%) students indicated that they never used e-Learning for their studies (G: n = 3, 5%; I: n = 21 ,18%; UK: n = 3, 8%).

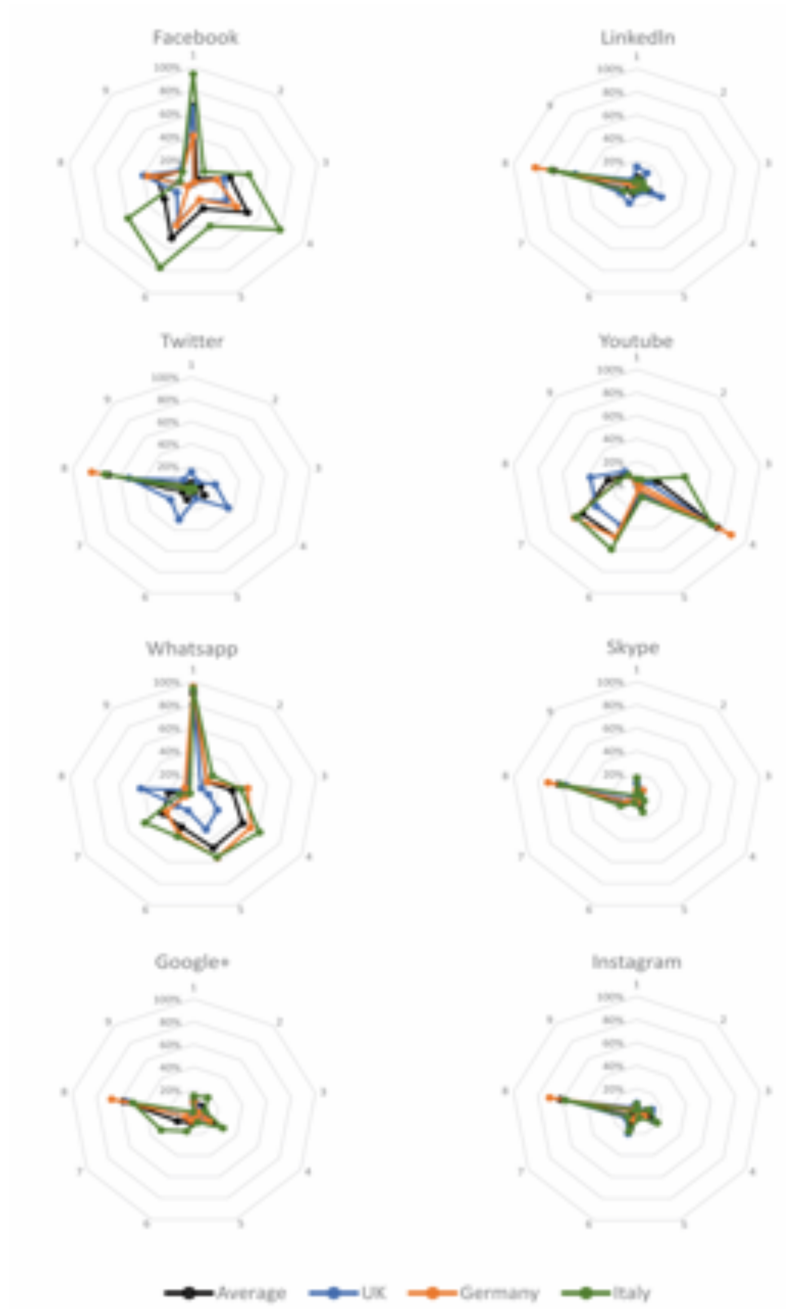

Figure 1: Answers in % of the total amount of participants and within each national cohort (Germany: n = 68, Italy: n = 121, United Kingdom: n = 40) to the question what the single social media were used for in the context of the students´ studies (Given answers: 1 = To contact peer students for study learning purposes; 2 = To contact teachers for study learning purposes; 3 = To post knowledge contents; 4 = To receive knowledge contents; 5 = To discuss study related knowledge contents; 6 = To follow discussion about knowledge contents; 7 = I would appreciate, if my teachers would use it; 8 = I do not use it; 9 = I used it for other purposes)

The frequency of students´ use of different e-Learning tools for acquisition of knowledge for studies is shown in figure 2. Taking into account some differences in national preferences, the average majority of students often used powerpoint lessons (77%, sometimes: 20%) or online copies (59%, sometimes: 24%) of their own university followed by electronic scientific papers (53%, sometimes: 35%). Also other rather classical learning tools besides plain texts and powerpoints, such as videos about techniques and methods were frequently used (often: 31%, sometimes: 58%). On the other hand, rather newer tools of the digital age, such as podcasts (often: 3%, sometimes: 16%), blogs (often: 2%, sometimes: 24%), MOOCs (often: 2%, sometimes: 24%) or serious games (often: 1%, sometimes: 5%) did play a rather minor or no relevant role in the evaluated population.

The usage of different online sources by students for acquisition of knowledge or scientific information for their studies is depicted in figure 3.

When they used e-Learning materials (multiple answers permitted), 157 (69%) of all study participants stated those were offered by their university with free access (G: n = 53, 78%; I: n = 69, 57%; UK: n = 35, 88%). 78 (34%) students used free accessible materials not offered by their university (G: n = 33, 49%; I: n = 38, 31%; UK: n = 7, 18%). 9 (4%) students had also used charged materials (not offered by their university) (G: n = 2, 3%; I: n = 5, 4%; UK: n = 2, 5%). 30 (13%) indicated that they did not use e-Learning materials at all (G: n = 8, 12%; I: n = 21, 17%; UK: n = 1, 3%).

162 (71%) of all students agreed in the statement that they would appreciate, if their institution offered more e-learning materials for their studies (G: n = 46 / 68%; I: n = 95 / 79%; UK: n = 21 / 53%).

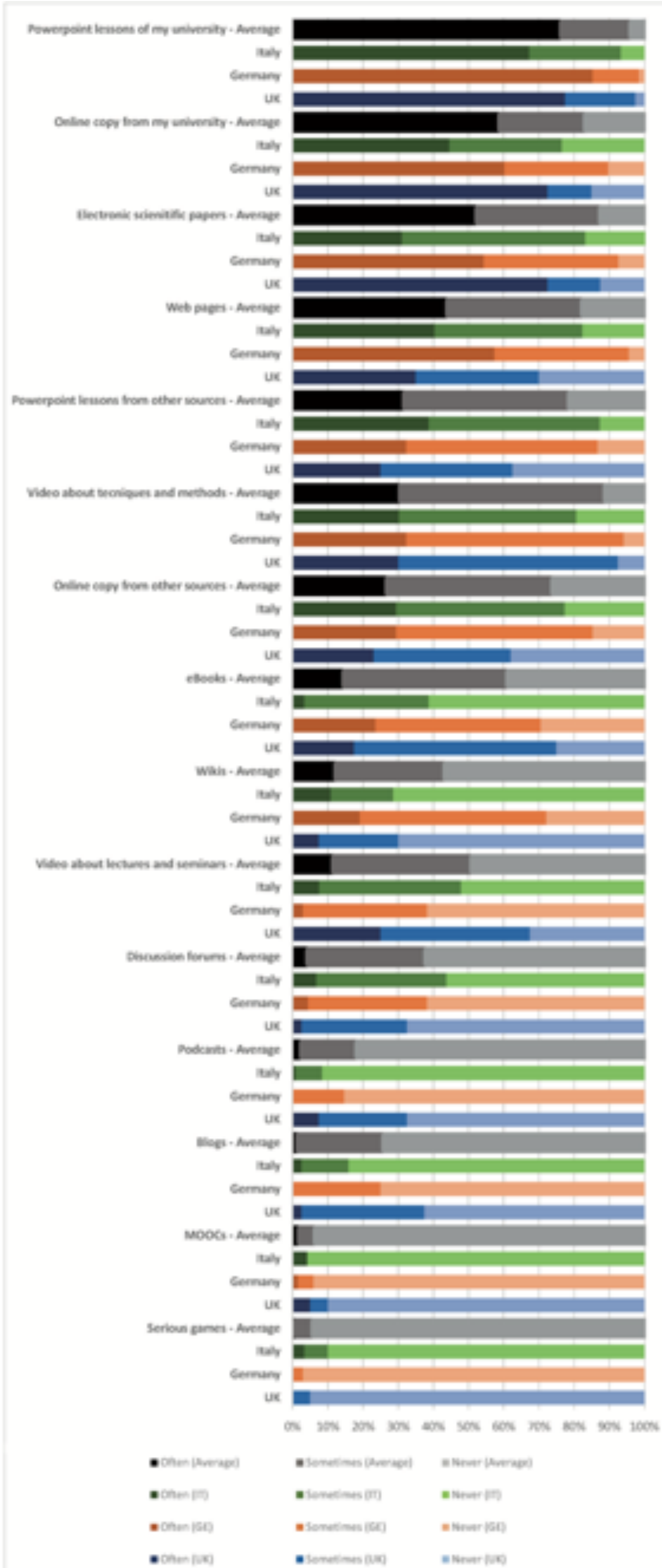

Figure 2: Students´ ratings of the single items of the question "Which of the following e-Learning tools do you use to acquire knowledge for your studies?" (n = 229; multiple choice permitted; answers given in % of the absolute number of participants)

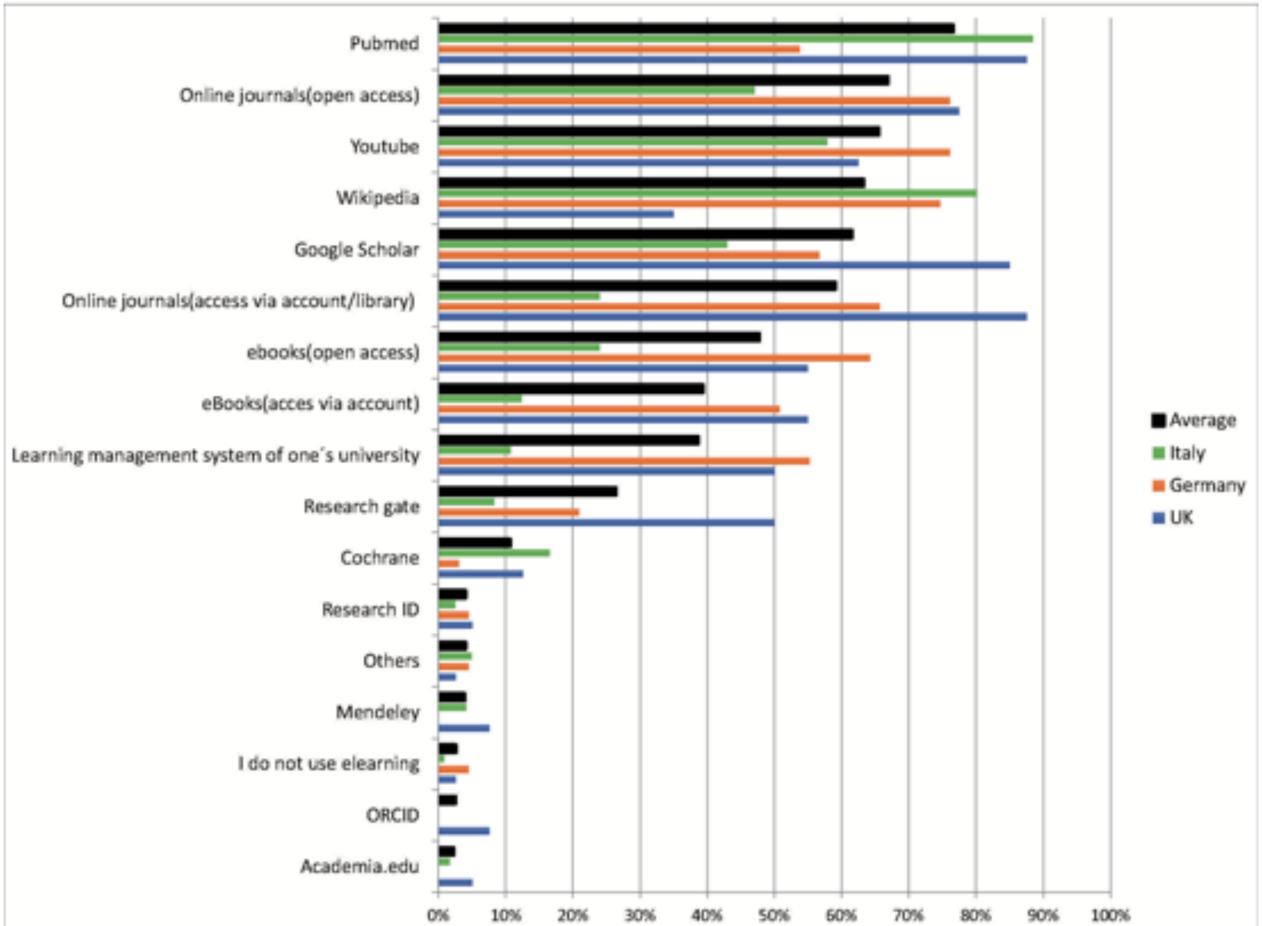

Figure 3: Students´ ratings of the single items of the question "Which of the following online sources do you use to acquire knowledge or scientific information for your studies?" (n = 229; multiple choice permitted; answers given in % of the absolute number of participants)

Free-text answering options within the questionnaire resulted mostly in few answers and were thus not considered for analysis due to missing explanatory power. Only the question for wishes for further e-learning materials was answered by altogether 71 (31%) of all 229 participants, could thus be analysed and revealed as main areas of interest:

- More and free access to scientific articles or e-books (n = 28, 12%)
- Online materials from their university´s lessons (e.g. lecture videos, PowerPoints, scripts...) (n = 15, 7%)

- Recommendations for / links to learning materials from other sources (e.g. videos, webpages...) (n = 13, 6%)
- Interactive materials (e.g. quizzes or exam preparation tests) (n = 7, 3%)
- Some features were wished only by single students (e.g. podcasts or “serious games”)

4.1.5. Discussion

Incorporating digital contents to promote learning has become a natural part of academic life in health sciences. This multi-center and multi-national orienting survey evaluated the usage attitude and extent of use of social media and e-learning for academic communication and learning among students in the fields of sports and exercise sciences. To our knowledge, it is the first study focusing on this aspect in these health disciplines.

The analysis of the use of social media showed that certain tools such as Facebook, WhatsApp and YouTube were more often used than others, which can be explained by their individual features. YouTube used by more than 75% of all participating students as the most frequent medium for receiving content, reinforcing the finding that 89% of students used video ‘sometimes’ or often’ for acquiring knowledge about techniques or methods. While also other studies have shown students’ preference for videos as learning tools (Hampton, Pearce, & Moser, 2017), especially in the field of sport sciences, the positive value of visualization of movements and tactical team approaches appears to be obvious. WhatsApp and Facebook were most widely used in the study population and, also showing the broadest use for different learning purposes, which is most likely derived from the integration of these social media into the daily life of most students. Interestingly, WhatsApp was mostly used to contact peer students for study learning purposes or for discussing study related knowledge contents, while Facebook was more often indicated for following discussions. LinkedIn, Instagram, Twitter, Google+ and Skype played only rather minor roles for students´ studies in the questions covered here. However, as could be seen with the peaks among UK students for Twitter for receiving knowledge or following discussions about knowledge contents, it can still be assumed that depending on individual courses and study related settings, single social media might well be included in the studies (Hennessy, Kirkpatrick, Smith, & Border, 2016). Such national differences in the proportional usage of social media as with Twitter could also be seen for Facebook among Italian participants. However, whether these differences are attributable to broader preferences of social media use in the wider populations of those nations (Saw, et al., 2013) cannot be answered by this study design.

It was remarkable that communication with their teachers via social media was still not common for the vast majority of students, even though efficient examples can be found in literature (Hennessy, et al., 2016). However, due to a presumably further necessary change in attitudes towards social media among many faculty members nowadays, this kind of communication will rather be based on individual teacher´s initiatives than on generalized institutional approaches for the near future (Manca and Ranieri, 2016). Social media will most likely not serve as classical learning tools in this context, but as useful and accepted facilitators and enabler for the distribution of and communication about learning contents.

According to the results, e-learning was used weekly by at least half of the participating students and by another quarter at least once a month. The leading internet sources for an acquisition of knowledge by most students were PubMed (77%) and open access journals (67%) which suggests that most students knew about good scientific approaches to data sources. The high value of YouTube (66%) among the evaluated population might be explained by the high importance of visualisation of motions sequences or tactical aspects of performance in sport and exercise sciences (Lance, 2007). Wikipedia was, with national differences, used by almost two thirds of the students (63%) and was thus in the overall “top 3” sources of knowledge – a finding which goes along with findings from other studies (Judd and Elliott, 2017). This is why we would suggest academic societies to be aware of the influence of freely available online information and thus to strengthen high quality online sources and platforms as reliable scientific bases of knowledge.

Even though new digital learning materials have been introduced and used in academic education for many years (e.g. podcasts, blogs, wikis or MOOCs) (Boulos, Maramba, & Wheeler, 2006; Griffin and Shrier, 2016), still the majority of participants in this study indicated a preference for the classical teaching materials such as PowerPoints (77%) or scripts (59%), followed by scientific articles (53%). As this study has not analysed the current provision of e-learning tools by the participating universities, it is not clear whether tools such as podcasts or videos had been available or would have been used more if provided by the institutions. This should be addressed in further studies.

The importance of universities´ engagement in digital learning for the imprinting of their students may also be estimated by our data that most participants preferred e-learning materials from their own university over other available online sources. The vast majority of participating students stated that they would appreciate more offerings of e-learning tools by their faculties. Definitely, not all wishes will easily be realized by faculties and there should always be some scepticism to just follow the latest technological trend in e-learning (Cook and Triola, 2014). However, a stable consistency of integration of some highly appreciated tools could raise the familiarization of students with the use of digital learning and could also establish a basis for the acceptance of other digital learning tools in the students´ further academic training. It should be appreciated that new digital tools might soon set the basis for future common ways of teaching (e.g. virtual or augmented reality) (Duking, Holmberg, & Sperlich, 2018).

For the future, faculties in sports and clinical exercise sciences should foster international educational collaborations for an exchange of successful digital teaching concepts or also single tools. It will most presumably also be important for an academic institution to train their students in the use of social media and digital tools to bring their opinion and knowledge across. One aspect, which might be addressable in this context, could be a tendency of students in our data to passively use the social media as consumers rather than actively posting with them. Such an active use of digital media will not only be important for working in academic jobs, but also for postgraduates´ engagements in sports industries or fitness companies.

Thus, especially regarding the use of social media, we recommend to strengthen the digital competency of students in sports sciences by their academic institutions. Concerning the established modern way of learning with digital media, academic institutions should use the possibility for international collaborations to complement and enhance the quality and diversity of their digital learning offerings to broaden the horizon of their students.

Among the drawbacks of this study is that neither was the number of students representative for each country nor were the students´ national within this survey similar.

Also, the voluntariness of participation might have posed a selection bias even though a bias of Internet affinity should have been reduced by the use of hard copies. The goal of providing a broad overview of the topic inhibited a deeper insight in specific questions like the kind of videos used for learning or quality of contents dealt with on social media. Also, the attitude of the students was presented without comparative information of the faculties´ learning strategies or the teachers´ attitude to this topic, which should both be taken into consideration when analysing this topic comprehensively. In the future, more universities and more countries should be included in surveys of this kind. Also the faculties should be evaluated for their digital educational theoretical concepts and their perspective of these issues. The performed comparison of different social media (e.g. WhatsApp as classical communication tool versus content platforms like YouTube) may be difficult in the context of a balanced scientific study approach. However, in our chosen survey design, we primarily aimed at detecting the general use of social media by the focused students population. Future research in the field of social media will have to differenciate more detailed between the single tools, their structure and contentual focus areas

Conclusion

This survey showed the fairly high use of social media and e-learning tools by students in sports, health and exercise sciences to enhance and support their studies. While certain social media like Facebook, WhatsApp or YouTube were used more often and more widely than others, the latter might have its potential in single defined teaching settings. Digital tools have taken a firm place as learning sources for most students and they would like more e-learning provision from the universities. However, despite much accordance, international cooperation projects should consider national preferences and differences in attitudes towards single social media and e-learning tools.

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4.2. Study 2

Instructing ultrasound-guided examination techniques by a social media smartphone app

Rigamonti L[1], Kahle P [2], Peters H [3], Wolfarth B [4], Thouet T [5], Bonaventura K [1,6], Back DA [7,8]

1 University Outpatient Clinic, Center of Sport Medicine, Department Sport and Health Science, University of Potsdam, Potsdam, Germany
2 Department of Cardiology, Kerckhoff-Klinik GmbH Bad Nauheim, Bad Nauheim, Germany
3 Dieter Scheffner Center for Medical Teaching and Educational Research, Charité – Universitätsmedizin Berlin, Berlin, Germany
4 Department of Sports Medicine, Humboldt University, Charité – Universitätsmedizin Berlin, Berlin, Germany
5 Department of Sports Medicine, Humboldt University, Charité – Universitätsmedizin Berlin, Berlin, Germany
6 Clinic for Cardiology and Angiology, Ernst von Bergmann Hospital, Potsdam, Germany
7 Clinic of Traumatology and Orthopedics, Bundeswehr Hospital Berlin, Berlin, Germany
8 Dieter Scheffner Center for Medical Teaching and Educational Research, Charité – Universitätsmedizin Berlin, Berlin, Germany

Reference

Rigamonti L, Kahle P, Peters H, Wolfarth B, Thouet T, Bonaventura K, et al. Instructing Ultrasound-guided Examination Techniques Using a Social Media Smartphone App. Int J Sports Med. 2021;42(4):365-70.

4.2.1. Abstract

Social media applications on smartphones allow for new avenues of instruction in sports medicine and exercise sciences. This study tested the feasibility of instructing health care personnel through videos of ultrasound vascular measurements distributed by a social media messenger application. After two training sessions with an ultrasound device, voluntary physicians (n = 10) and nurses (n = 10) received a video for the performance of an ultrasound-guided determination of intima-media-thickness and diameter of the femoral arteries via a social media messenger application. All participants examined the same healthy human subject. There was no significant difference between the groups regarding overall time of performance, measurements of the femoral arteries, or a specifically designed “assessment of mobile imparted arterial ultrasound determination” score. The physicians group achieved significantly higher scores in the established “objective structured assessment of ultrasound skills” score ($p = 0.019$). Approval of the setting was high in both groups. Transmission of videos via social media applications can be used for instructions on the performance of ultrasound-guided vascular examinations in sports medicine, even if investigators´ performances differ depending on their grade of ultrasound experience. In the future, the chosen approach should be tested in practical scientific examination settings.

Keywords: Instruction, healthcare personnel, social media, ultrasound, video

4.2.2. Introduction

As sports medicine affects the care of nearly every part of physiological function and human health, research in this field can offer many intersections to other medical disciplines. Pathologies of the cardiovascular systems pose relevant burdens on societies worldwide [1, 2] such as atherosclerosis, one of the leading causes for acute coronary syndromes, cerebrovascular or peripheral arterial diseases [3], which is harming patients significantly and is counting for high costs in the social services [2]. Pathologies in affected arteries are mostly linked to the arterial wall [4], making changes e.g. in the intima-media thickness (IMT) good predictors of cardiovascular events [5]. The most common and reliable non-invasive method in the detection of atherosclerotic diseases is ultrasound [6]. Examining changes in the arterial structures of young adults can help to learn more about pathologies themselves. Studies have demonstrated the impact of exercise training on the modification of vascular structures [7] with an enlargement of the arterial diameter and a decrease of the IMT in athletes' vessels [7, 8]. However, the number of athletes, which can be reached for scientific examinations in single institutions, may be limited [9, 10]. Multi-centre approaches [11, 12] can be beneficial to foster collaborations of scientists for research issues in small-sized populations of athletes. As instructing investigators about defined measurement techniques is necessary for a successful study protocol, digital features of information transmission could be efficient with long-distance collaborating institutions to help to establish a common understanding of certain methodologies [13-15]. The digital transformation of our society allows for new avenues of teaching and instruction in the medical field [13]. Tools like videos have already proven to be reliable for imparting practical skills in medicine and exercise sciences [14, 16, 17]. Additionally, social media have been shown to be well accepted and used by researchers [13], but also in clinical fields for communication [15], transmission of ultrasound results [17], or training of clinical techniques [14]. Especially smartphone messenger applications offer advantages like constant mobile availability for users, easy integration of audio-visual files, and quick lines of communication also for professional purposes [18, 19]. This also holds true regarding the digital instruction of the investigating personnel, be they experienced or inexperienced personnel [20, 21]. This might be of interest for research projects, where also young clinical exercise scientists may participate with the performance of instructed investigations techniques being their delegated task [22, 23].

The aims of this study are: 1) to investigate the feasibility of instructing investigators about defined ultrasound-guided arterial measurements with videos distributed by a social media messenger application; and 2) to analyze and compare in this context the influence of participants´ previous familiarity and experience with ultrasound examination techniques on the performance.

4.2.3. Materials and Methods

Organizational study preparation

In advance of the study, the technique of measuring the Intima-Media-Thickness (IMT) and the diameter (DM) of the femoral artery by B-mode with an ultrasound-device (HD7 XE Ultrasound system, Philips, Amsterdam, Netherlands) was performed by a specialist of cardiology on a healthy male human subject and recorded as teaching video with a mobile phone (Sony Xperia SZ1 Compact, Sony Mobile Communications, Inc., Tokio, Japan). Rules of informed consent and warranty of anonymity both for the doctor and the human subject were granted. The study concept was approved by the responsible local ethical commission. The study also meets the ethical standards of the International Journal of Sports Medicine [24].

Study design

Voluntary physicians (n = 10) and nurses (n = 10) were recruited and randomly assigned to anonymised code numbers, after having given their informed consent on participation. Ultrasound had regularly not been used by the nursing personnel for their jobs, and none of the participants of both groups had been familiar with the specific ultrasound device. The protocol contained a three-step approach to establish a similar basis of knowledge and skills among all subjects:

- **Two days before** the main experiment, an identical introduction into the device and its handling by a specialist of cardiology took place individually with each participant. The task was to perform ultrasound measurements of the IMT and DM on the right carotid artery in a healthy male subject. There was no time limitation and the participants could ask every question of interest.
- **One day before** the main experiment, participants were asked to individually repeat the ultrasound measurements of the IMT and DM on the right carotid artery and as addition also on the left carotid artery of the same subject. The specialist now answered questions or provided help only when explicitly asked for. In the evening, participants received the video to their smartphones with the messenger application WhatsApp (WhatsApp Inc., Mountain View, CA, USA), which had already been in use by all of them. Contact to the study team via mobile application was possible (any contact data was deleted immediately after the study).

- **On the day of the main experiment**, participants were asked to perform measurements of the femoral arteries of the same subject, as shown in the teaching video with obtaining representative images of the ultrasound examinations. The ratio of the arterial data of each the left versus right side was to be determined by the participants. During examination, re-checking of the instructions provided on the smartphones was permitted. Participants performed the examination on their own, rated by two independent observers.

Inclusion criteria were the status as an examined physician or nurse (in the given setting, a specialization of the nursing personnel in ultrasound diagnostics could be excluded), use of a smartphone and the existing use of the messenger WhatsApp.

Examination conditions

Each examination took place in a room with mean temperature. The subject lay down on an examination stretcher in supine position. Blood pressure was taken before the examination and an ECG was attached during measurement. To exclude interferences with inter-individual anatomical differences, all examinations were performed on the same 35-year-old healthy human male subject. For standardization and control of food intake, the subject was asked to avoid specific liquids like caffeine and to consume the same kind of food 24 hours before the single examinations.

Scores and evaluations

Participants´ performance was analysed individually by two independent observers with the OSAUS-score (objective structured assessment of ultrasound skills) [25] and another score, which had been specially designed for this study (assessment of mobile imparted arterial ultrasound determination - AMIAUD, Tab. 1).

AMIAUD (assessment of mobile imparted arterial ultrasound determination) score

Tab. 1: Score for the “assessment of mobile imparted arterial ultrasound determination” (AMIAUD), created specifically applied study protocol. In the rating scale, only three points were connected with descriptive anchors.

1. **Clear understanding of the examination procedure and required measurements** (after using app and video)	1 Understanding of procedures not recognizable	2	3 Understanding with markable delays *(re-checking the video in 50% of the procedural steps; relevant problems with reproducing the video contents in the examination)*	4	5 Understanding clearly recognizable, procedures fluent *(If App is used, then only „informatively“ a few times and without impeding the examination flow)*
2. **Technical Handling of the digital mode of communication and instruction** *(Receiving and watching the digital tool – here video – on demand)*	1 Not possible or with severe problems *(e.g. video/sound cannot be started)*	2	3 Handling difficult or delayed *(e.g. due to problems when opening or watching the video via app)*	4	5 Handling without problems *(Video can be viewed on demand, even during examination performance, if needed)*
3. **Adjustment of the given ultrasonic sets (Positioning of the ultrasound transducer regarding anatomy)** *(in the „final“ frozen ultrasonic screen)*	1 Correct positioning not possible	2	3 Positioning with clear deviations from the given example in the video	4	5 Positioning as demonstrated in the video
4. **Correct measuring of the arterial Intima-Media-Thickness (IMT)** *(in the „final“ frozen ultrasonic screen)*	1 Measurements wrong (e.g. wrong vessel) or not possible	2	3 Measurements with clear mistakes *(e.g. wrong identification and choice of the IMT in the final shot)*	4	5 Measurements as demonstrated in the video
5. **Correct measuring of the arterial diameter** *(in the „final“ frozen ultrasonic screen)*	1 Measurements wrong (e.g. wrong vessel) or not possible	2	3 Measurements with clear mistakes *(e.g. wrong identification and choice of the diameter in the final shot)*	4	5 Measurements as demonstrated in the video
6. **Correct calculation of the results (calculation of ratio)**	1 Results not or incorrectly calculated	2	3 Results partially correct *(50% correct, or basic values correct but wrong calculation of the ratio)*	4	5 Results calculated as demonstrated in the video

Tab. 1: Score for the “assessment of mobile imparted arterial ultrasound determination” (AMIAUD), created specifically applied study protocol. In the rating scale, only three points were connected with descriptive anchors.

The time of each examination round of the main experiment was noted. Additionally, evaluation sheets were given to every participant (18 questions; 5-point Likert-scaled or free text answering options), asking for previous experiences with the applied media, experiences with digital and social media in their professional life and their opinion of the tested setting. Results were compared between the two groups.

Statistics

Data was analysed with the software IBM SPSS Statistics (Version 23.0, IBM Corp., New York, USA). To compare the evaluation and examination results in between the two groups, the Mann-Whitney-U-Test was applied. Cronbach´s Alpha was determined as correlation coefficient for the independent observers of the final examination. Likert-scaled evaluation data was analysed using the chi-square distribution. Non-scaled evaluation data was analysed by means of descriptive statistics, while free text based answers were checked by two of the authors for repetitive sequences.

4.2.4. Results

Demographic data

The participating nurses (5 male, 5 female) were on the average 35.5 years old (SD 6.9), and had been practicing for 15 years (SD 8.6) as scrub nurses (n = 4), ICU nurses (n = 3) or regular ward nurses (n = 3).

The participating physicians (5 male, 5 female) were 38.7 years old (SD 8.4), and had been practicing for 11 years (SD 9.8). They were from anaesthesia (n = 4), surgery (n = 3), general medicine (n = 2) and neurology (n = 1).

Participants´ use of social media and video learning

When asked for previous use of videos for learning about medical techniques, 8 nurses indicated often/rather often and 2 rather seldom, while 7 doctors indicated rather often, 1 sometimes, 2 rather seldom. One nurse used the smartphone “daily or at least 2x/week“ for job purposes (e.g. special apps, internet search), 2 “at least 2x/month“, 5 “1x/month or less“, 2 “never” versus 6 doctors used the smartphones “daily or at least 2x/week“, 3 “at least 2x/month“, 1 “never”. Social media programs indicated to be used by nurses were WhatsApp (n = 10), YouTube (n = 9), Facebook (n = 6), Skype (n = 4), Google+ (n = 3), Instagram (n = 2) and Twitter (n = 1). Doctors used WhatsApp (n = 10), YouTube (n = 5), Facebook (n = 4), Skype (n = 3) and Google+ (n = 1) (multiple choice permitted).

Evaluation of the experimental setting

Participants´ rating of questions concerning the method used as well as digital materials were without significant differences (Fig. 1). No technical problems occurred with sending, receiving, watching, or using the study video on demand.

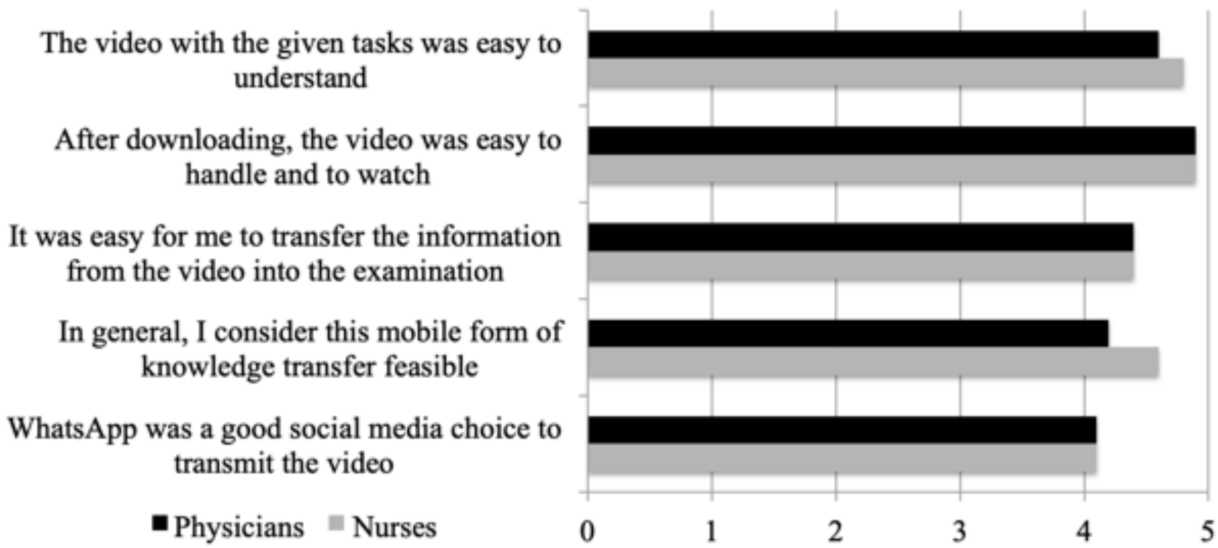

Fig. 1: Participants´ rating of questions concerning the used method and digital materials (Likert-scale´s range: 1 = I completely disagree, 2 = I disagree, 3 = neutral; 4 = I agree, 5 = I completely agree).

Asked for another preferred form of social media for presentation of the video, 4 nurses and 2 physicians indicated YouTube. In free text comments, the participants named as advantages of the chosen mobile information transfer via social media: Freedom of time and space (n = 9), easy distribution of information (n = 6) and the possibility to repeatedly play the videos (n = 3). As disadvantages of the chosen setting were mentioned: Lack of a direct contact person for questions (n = 8), no possibility for a control of performance (n = 5), potential amount of contents versus a sensible length of a video (n = 1) and questions of data security (n = 1).

Examination results and scores

Nurses needed 15 minutes and 24 seconds (SD: 6 minutes 30 seconds) and physicians needed 12 minutes and 43 seconds (SD: 5 minutes 4 seconds) to complete the given task ($p = 0.579$).

With an inter-observer correlation coefficient of 0.891 for the OSAUS score, nurses achieved an average assessment rating of 18.9 (SD: 2.1) and physicians of 21.5 (SD: 2.4) ($p = 0.019$). The AMIAUD score had a correlation of 0.837 with an average rating of 26.1 (SD: 2.6) for nurses and 27.6 (SD: 1.8) for physicians ($p = 0.165$).

The mean calculated ratio (right/left side) for IMT was 0.986 mm (SD: 0.115) for nurses and 0.941 mm (SD: 0.230) for physicians ($p = 0.247$; reference value by specialist measurement: 0.957 mm). The mean calculated ratio value (right/left side) for DM was 1.066 mm (SD: 0.069) for nurses and 0.999 (SD: 0.079) for physicians ($p = 0.089$; reference value by specialist measurement: 1.024 mm).

4.2.5. Discussion

The impact of digitalization on modern life can be used for new strategies to improve procedures in research projects. Scientific investigations of human pathologies in multi-centre or international collaborations need standardized examination protocols, traditionally guided by written documents. To enhance the visualization of methodical procedures and thus to improve understanding of their performance for investigators, who might have different backgrounds and knowledge of certain examination techniques, new digital ways for imparting information should be investigated. The study presented here aimed to evaluate the possibilities of instructing investigators on defined arterial measurements by videos distributed with a social media messenger application.

Ultrasound familiar and non-familiar investigators were explained an ultrasound device and measurement techniques and then evaluated by questionnaires and scoring systems.

Even though there was a non-significant tendency for the nursing group to take longer to perform the examination, both groups achieved similar ultrasound results. However, significant differences could be found partly in the objective scoring systems for ultrasound performance. Different scoring systems have been described in assessing ultrasound skills so far, either by focusing on investigators´ general performance [26], their confidence levels or the quality of image ratings [17]. A good and reliable way to reproduce the assessment of ultrasound competence was given by the here chosen OSAUS score [25]. However, because of the new digitally transmitted instructions of examination methodology, the AMIAUD score was additionally created. The results may consequently be interpreted in the way that the pre-existing familiarity and experience with ultrasound examinations in the physicians´ group lead to a significantly better OSAUS score. Furthermore, considering the missing significant differences in the final results for the determined ultrasound results, the absence of significant differences in the AMIAUD score may suggest that the use of digitally supported instruction can have helped to overcome the leap in experience when performing the final examination. As here, the positive influence of mobile video-based instructions on the skill performance of healthcare users has also been shown for other medical fields and should be further investigated in the future [14].

Transmitting information by digital means beyond text documents has already been well established in health sciences [14, 16]. In this study, all participants highly appreciated the chosen approach. Concerning the digital instruction tool, this might be explained by the fact that the examination technique could be well depicted by the voice-guided video. Videos have been well-implemented into medical teaching [27]. Transmitting information about the examination setting with videos might thus be integrated as a supportive supplement into protocols of future multi-centre studies. However, the study participants´ comments also suggested that length and quality of a video would be important, as these factors might influence users´ acceptance.

The chosen messenger application WhatsApp has been described for different indications in science and medicine [18, 19]. Still, it has to be regarded as mere example of a social media tool, as various studies have sufficiently used other social media for information transmission in medicine, like e.g. YouTube [28]. The use of the social media form will also depend on aspects like familiarity of its users and the study context [29].

When digitally transmitting data of any subjects, data protection laws have to be strictly followed [30], alongside with a close interaction with ethical committees. In this case, high care was taken that no personal details of the filmed subjects were recognizable. Depending on the chosen study setting [16], this way of anonymity might be hard to achieve creating the need for the post-processing of a video (e.g. for covering faces, tattoos etc.), leading to an increased effort in production.

Among the limitations of this study, it has to be critically mentioned that the chosen setting was adjusted to the research question. Consequently, the complexity of other study methods might create challenges for a video-based instruction when involving more equipment, longer procedure durations, or handling of machines. Regarding the underlying intention to implement this kind of digitally supported methodology transmission into multi-centre cooperative research projects, this has not completely been depicted by the given setting, as the recruited participants were not actively involved in scientific research projects. It can also be critically discussed that both groups received trainings in the needed device and techniques directly in advance, what might have diminished differences between them. However, this was taken into account due to the intention to focus on the evaluation of the feasibility to transfer information with digital means and social media. Finally, the methodology and the relatively small number of participants could not yet allow a conclusion on the efficacy of the tested setting. Not only other examination settings, but also higher numbers of subjects should be included in further studies in this context.

In further steps, the evaluated digital form of distributing instructional materials via social media channels should be tested for its applicability in a clinical study protocol. Here, it has to be taken into account that WhatsApp cannot be regarded as a legally acceptable form of communication in the medical setting, at least when it comes to transmission of patient data beyond anonymous videos like in the given setting. In the future, the usability of digital features for supporting the organization and performance of clinical research trials will have to be further investigated. In this context, also more interactive settings will also have to be evaluated for their potential use, like e.g. augmented reality scenarios [31].

Conclusions

Social media smartphone applications can be used to instruct investigators about defined examination techniques. In the given setting, a different background on experience and familiarity with the applied technique did still lead to similar examination findings in the two groups after use of the app-provided video, even though performance scores themselves showed significant differences. The chosen approach will have to be evaluated for its applicability in examination protocols of long-distance study approaches.

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4.3. Study 3

Use of an Augmented Reality Device for Remote Supervision of Ultrasound Examinations: International Exercise Science Project

Lia Rigamonti, MSc [1], Matteo Secchi, BSc [2], Jimmy B Lawrence, MSc [3], Luca Labianca, MD [4], Bernd Wolfarth, MD [5,6], Harm Peters, MD, MPHE [7], Klaus Bonaventura, MD [1,8], David Alexander Back, MD, MBA [7,9]

1. University Outpatient Clinic, Sports Medicine & Orthopaedics, Department of Sport and Health Sciences, Center of Excellence "Cognitive Sciences", Faculty of Human Sciences, University of Potsdam, Potsdam, Germany.
2. Italian Association of Hydrotherapists and Newborn Educators (AIIEN), Section of Rome, Rome, Italy.
3. Department of Health and Physical Education, Mercer County Community College, West Windsor, NJ, United States.
4. Department of Orthopaedics and Traumatology, S. Andrea Hospital, Sapienza University of Rome, Rome, Italy.
5. Department of Sports Medicine, Charité - Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Berlin, Germany.
6. Department of Sports Medicine, Humboldt University Berlin, Berlin, Germany.
7. Dieter Scheffner Center for Medical Education and Educational Research, Charité - Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Berlin, Germany.
8. Department of Cardiology, Ernst von Bergmann Hospital, Potsdam, Germany.
9. Department of Traumatology and Orthopaedics, Septic and Reconstructive Surgery, Bundeswehr Hospital Berlin, Berlin, Germany.

Reference

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4.3.1. Abstract

Background: Support for long-distance research and clinical collaborations is in high demand and has increased owing to COVID-19 travel and social contact restrictions. New digital approaches are required for remote scientific exchange.

Objective: This study aims to analyze the options of using an augmented reality device for remote supervision of exercise science examinations.

Methods: A mobile ultrasound examination of the diameter and intima-media thickness of the femoral and carotid arteries was remotely supervised using a head-mounted augmented reality device. All participants were provided in advance with a link to a YouTube video of the technique. In part 1, 8 international experts from the fields of engineering and sports science were remotely connected to the study setting. Internet connection speed was noted, and a structured interview was conducted. In part 2, 2 remote supervisors evaluated 8 physicians performing an examination on a healthy human subject. The results were recorded, and an evaluation was conducted using a 25-item questionnaire.

Results: In part 1, the remote experts were connected over a mean distance of 1587 km to the examination site. Overall transmission quality was good (mean upload speed: 28.7 mbps, mean download speed: 97.3 mbps, mean ping: 21.6 ms). In the interview, participants indicated that the main potential benefits would be to the fields of education, movement analysis, and supervision. Challenges regarding internet connection stability and previous training with the devices used were reported. In part 2, physicians´ examinations showed good interrater correlation (interclass correlation coefficient: 0.84). Participants valued the experienced setting as highly positive.

Conclusions: The study showed the good feasibility of the chosen design and a highly positive attitude of all participants toward this digital approach. Head-mounted augmented reality devices are generally recommended for collaborative research projects with physical examination–based research questions.

Keywords: augmented reality; ultrasound; social media; remote; exercise science

4.3.2. Introduction

Background

International collaborations play an important role in addressing research questions in almost every scientific discipline [1]. Exercise science is highly interdisciplinary, without regional boundaries, and closely related to different areas of health care. For example, research on vascular changes in athletes [2] can help understand pathologies and global burdens, such as cardiovascular diseases [3]. Although sports techniques are often internationally organized and standardized [4], the number of athletes reached for investigations in a single research institution could sometimes be limited depending on the geographic location and the type of sport [5,6]. Multicenter studies are well established in clinical medicine [7,8] and have been used in clinical exercise science research [9]. It would be advantageous to facilitate collaboration among exercise science researchers worldwide for investigations with common research questions, especially with a small population of athletes.

In addition to the impact of the current COVID-19 pandemic with strict travel and contact restrictions and the usual long distances between collaborating institutions, there is a high demand for new digital solutions to bridge distances and contact barriers [1,10,11]. Different digital media or devices may enhance scientific and professional collaborations and thus the health of patients [12,13]. Various approaches have already been described in this context, with early possibilities such as communication or instruction via email or videos [14]. With the rise of the internet and its increasing capability, social media has become highly sophisticated and widespread in the everyday lives of people worldwide [15]. Consequently, this technology is also used for teaching and research purposes depending on individual features, such as direct interpersonal communication, scientific exchange [12], or instructions on medical examinations or surgical techniques [16].

Despite many promising aspects, many of these options lack real-time personalized participation and direct interaction of remote collaboration with partners and examiners in research settings. New digital modes of interaction may be used, such as augmented reality (AR), which can be defined as *technology that integrates digital information into the user´s real-world environment* [17] and is sometimes also referred to as mixed reality [18]. AR devices have already been practically used in the technical settings of business enterprises [19] and for procedural work in space [20]. However, their use in medicine remains experimental. Potential has been described, especially in undergraduate education [21] and in the context of instructing invasive techniques, such as surgery [22]. In some cases, head-mounted AR devices were used in a clinical setting, where magnetic resonance imaging data were made available directly into the vision of surgeons [23]. For example, in sports science, AR has been used to create volleyball court images to measure athletes' movements in a laboratory setting [24].

Aim and Hypotheses

This study addressed the feasibility of remote digitally supported exercise science collaborations using two different approaches.

In part 1 of the study, we hypothesized that it is possible to have different experts from various international locations remotely participating in an ultrasound examination setting using an AR device. In addition, their feedback on this method and its potential should be assessed.

In part 2 of the study, we hypothesized that it is possible to have different physicians performing the same ultrasound examination technique while being connected to 2 independent remote supervisors with an AR device.

4.3.3. Methods

Study design

This project consisted of two parts, both of which used the same examination technique to perform ultrasound-based measurements of the intima-media thickness (IMT) and the diameter of the femoral and carotid arteries. All measurements were performed using the same healthy male human subjects. The procedures or measurements were recorded in advance as videos [25]. For better mobility, a portable ultrasound linear array transducer (Lumify; Philips Healthcare) was chosen and linked to a cellphone (HTC Corp) with the appropriate app. The AR device used was a HoloLens 2 (Microsoft Corp) with Dynamics 365 Remote Access software (Microsoft Corp). Connections between participants were enabled by the Microsoft Teams software (Microsoft Corp). Participation in the study was voluntary, with no compensation, and anonymity was ensured. All participants provided informed consent. The ethical committee of the University of Potsdam approved this study (EA1/236/19).

Part 1: Remote expert connection and interviews

In the first approach, different professional experts in engineering and sports science were identified and asked for participation to obtain initial impressions of AR, both from a technical and scientific point of view. None of these participants had previous routine work experience with AR or HoloLens.

All participants received an email in advance with a description of the project design and a link to an examination video uploaded on a private YouTube channel, created specifically for this study (YouTube, LCC). After watching the video in advance, the experts then participated separately in the same setting, and the individual experts themselves were located internationally at their chosen location using their personal electronic devices. The physical location where the ultrasound examination was performed was Berlin, Germany. The standardized examination conditions for the human subject are described below in the *Examination Conditions* section. Remote live participation was made possible using an MS Teams (Microsoft Corp) digital meeting with the examiner wearing the HoloLens (Figure 1).

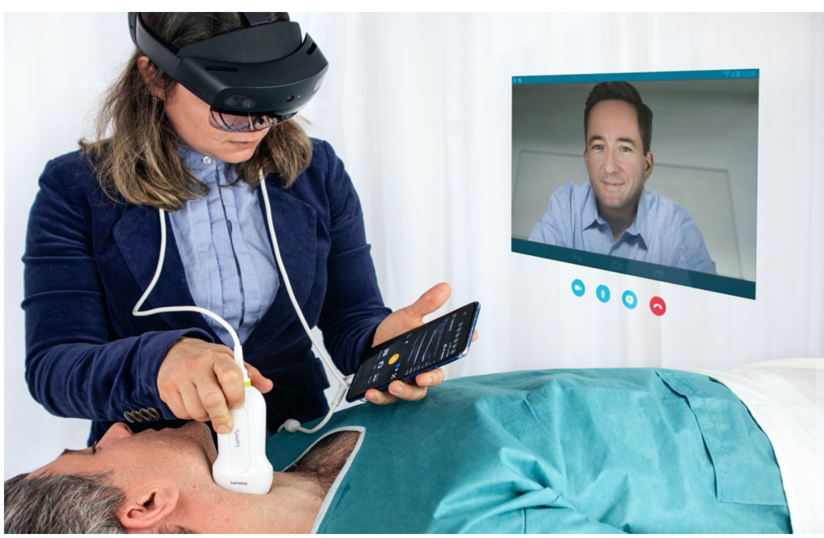

Figure 1: Example of the presented study setting with the investigator wearing the HoloLens 2 (Microsoft Corp) while performing the ultrasound examination with the Lumify transducer (Philips Healthcare).

The experts shared the examiner´s view with ultrasound determination of the IMT and diameter of the femoral and carotid arteries. They also presented the options of drawing arrows or lines into the vision of the HoloLens (Figure 2) and optional blending of pictures or videos into the vision display—features that could be used for visual instruction about precise ultrasound techniques (eg, location of the transducer) or measurements (eg, intrainterventional communication about designated landmarks) in the current setting. The internet download speed (mbps) and latency or ping (ms) of the observing experts were recorded. After this, they were asked 5 interview questions: (1) written or oral, regarding their perception of social media in general, (2) the remote connection mode in particular, (3) the potential for AR in exercise science and sports medicine, (4) other future digital areas with an impact on this field, and (5) challenges for digitalization in work-related settings.

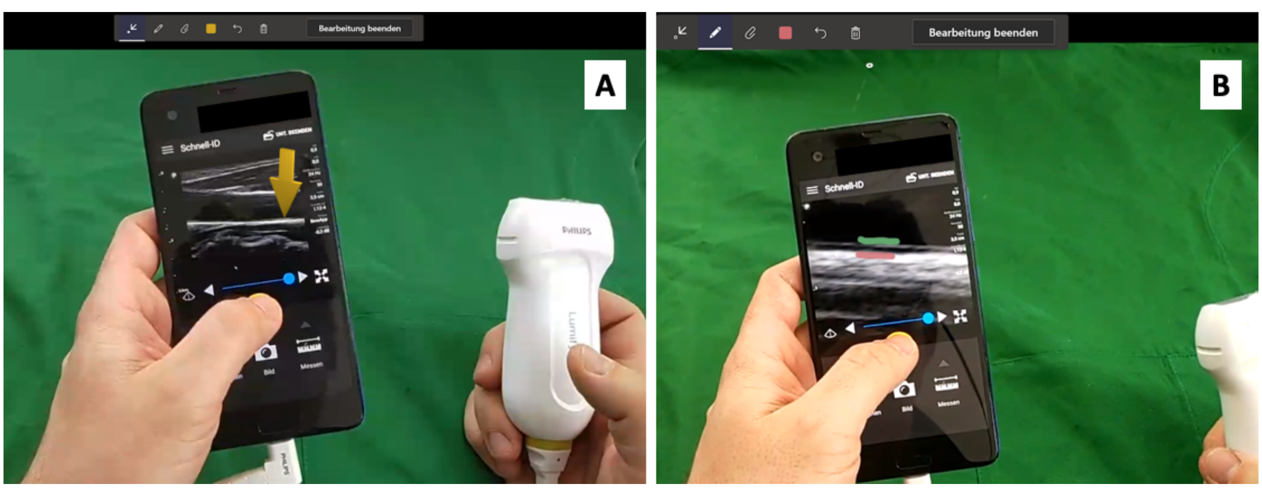

Figure 2: Examples of possible augmented reality indicators viewed while wearing the HoloLens device. (A) Arrow indicating a position to assist where to measure the intima-media-thickness. (B) Green and red lines drawn to indicate where the intima-media-thickness shall be measured.

Part 2: Examination setting with remote supervision

Before the examination, participating physicians were shown the use of the Lumify transducer along with its mobile app functions and the HoloLens. In addition, they received a link to the unlisted YouTube video, where the examination process and focus data were explained. The participants were asked to wear the HoloLens to measure the diameter and IMT of both the left and right femoral and carotid arteries. The measurements were accompanied by 2 independent remote supervisors, who were connected with their computer devices by an MS Teams digital meeting to the HoloLens and shared the view of the participating physicians. The performance was rated using the OSAUS (objective structured assessment of ultrasound skills) score (max 25 points; Multimedia Appendix 1 [26]) and a modified AMIAUD (assessment of mobile imparted arterial ultrasound determination) score (modification: the examiners were not asked to note the results), both recorded by supervisors. This adaptation was made because of the study setting, as the transducer and the mobile phone occupied both examiners' hands (now max 25 points; Multimedia Appendix 2 [25]). Each participant received an evaluation sheet with 25 questions (5-point Likert-scale, multiple-choice, or open-ended questions with text answer options). The topics were the following:

1. Demographic data (gender, sex);
2. Questions about social media and video-based transmission of knowledge (9 questions; 6 5-point-Likert-scaled, 2 multiple-choice questions, 1 open-ended question);
3. Use of the Lumify ultrasound transducer (5 questions; 4 5-point Likert-scale and 1 open-ended question); and

4. Questions about the practicability and acceptance of the HoloLens device (9 questions; 7 5-point Likert-scale and 2 open-ended questions).

Examination conditions

All examinations were performed with the same 39-year-old healthy male human subject lying in a supine position at a mean room temperature of 23°C. Electrocardiography was conducted during the examination, and blood pressure was assessed before the examination. The subjects were asked to consume the same kind of food and avoid caffeine or alcohol 24 hours before each examination to establish standardized conditions.

Data analysis

Data were entered in Excel (Microsoft Corp) and analyzed either descriptively or using SPSS statistics software (Version 27.0, IBM Corp). The interclass correlation coefficient was determined for the interrater correlation of the 2 independent observers of physicians´ examinations. Free text-based answers were checked by 2 of the authors for repetitive sequences. The ratio of the left and right arteries was determined. For vessel measurements, mean values and standard deviations were calculated for the scores, median values, and quartiles (IQR).

The expert interviews were analyzed for relevant topics using MaxQDA qualitative data analysis software (MaxQDA 2020; VERBI GmbH). Predominant themes were defined based on the subthemes and their particular topics.

4.3.4. Results

Demographic data

In part 1, the invited sports scientists (2 exercise scientists, 1 physical therapist, and 1 sports physician) were all male and had a mean age of 37 (SD 5.6) years, whereas the engineers (2 automotive engineers, 1 mechanical engineer, and 1 biomedical engineer) were also all male and had a mean age of 36 years (SD 2.9).

In part 2, the 8 participating physicians for the second examination setting (residents from the fields of surgery, orthopedics, anesthesia, and general medicine) were 4 women and 4 men with a mean age of 31 years (SD 2.8). The remote supervisors were a woman (36 years old) and a man (32 years old).

Part 1: Remote expert connection and interviews

Distance and internet connection

The average distance of the remote experts in their different cities in Germany, Italy, England, the Netherlands, Switzerland, and Saudi Arabia to the examination site (Germany) was 1587 (SD 1543) km. The internet connection of all final assessments was stable with a mean upload speed of 28.7 (SD 54.8) mbps, a download speed of 97.3 (SD 126.3) mbps, and a ping of 21.6 (SD 11.2) ms.

Interview questions

The interviews covered five topics, the answers to which are presented below.

Perception of social media

The participants were asked about (1) their perception of the technical aspects of obtaining information via the YouTube video, (2) the connection process to the HoloLens via Microsoft Teams, and (3) the internet connection during the examination. The experts stated that the technical aspects worked well overall, and the processes were easy, straightforward, and easily understood. It was positively reported that access to remote sessions was easily manageable from either a regular computer or mobile phone through a standard telecommunication program such as MS Teams. The YouTube video was rated as highly informative and useful. The connection went smoothly with only one minor connection problem reported when logging into MS Teams and once for a perceived low transmitted voice volume by the HoloLens.

Perception of remote connection mode

The general idea of remote digital presence in work- or research-related settings was associated with high approval, also described as an *amazing solution* important for the future, for example, when an expert cannot be physically present at a specific location but is needed. In general, collaboration can be enhanced. Great potential was seen in research teaching/supervision and within business/enterprise. Much of the potential was appreciated because of the current pandemic but also viewed favorably for pre- and postpandemic collaborations across large distances. The use of a relatively common and easy-to-use program may also lower the knowledge barrier required to interact with AR tools. Potential problems of poor internet connection or extended periods to connect were observed. However, compared with lacking alternatives, it is a fast response to urgent situations that require real-time support and allows for worldwide connection. A remote digital presence can be very handy, convenient, and comfortable for individuals.

Potential for augmented reality in exercise science and sports medicine

In the fields of sports science and sports medicine, the experts saw the greatest potential for the use of AR to spread knowledge with teaching and supervise from remote locations. Students and many other recipients (such as athletes) could benefit from this form of knowledge or skill transfer. This could better assist those who benefit from a more *hands-on* or interactive approach.

In sports and training, AR can be used for evaluative or observative analyses, for example, of single movements or patterns, and also as remote medical diagnostics.

A future potential was also described regarding connections with artificial intelligence. AR used concurrently with *smart programs* could, for example, analyze shapes, distances, and track movements (with the possibility of combining this with strength or other external sensors). In addition, deep learning algorithms can provide real-time analyses of an athlete's performance to coaches, trainers, scientists, and health/sports workers. Thus, beyond observational analysis, physicians could also perform AR-enhanced examinations combined with live data from circulation and tissues.

Future digital areas with an impact on exercise science and sports medicine

Participants were asked which areas and tools will affect sports science and sports medicine the most in the future. Most experts mentioned wearables and smart devices (n=56), followed by mobile apps (n=5), telemedicine (n=5), virtual/AR (n=5), education and training (n=4), artificial intelligence and big data (n=3), and social media (n=2). The participants reported several specific aspects of this technology's proposed impact: economic, educational (eg, clinical and practical skills training), increased data collection, and increased outreach with the possibility of reaching more people in remote areas.

Challenges for digitalization in work-related settings

On the basis of the experts' own experiences, they were asked what will be the biggest challenges for digitalization in work-related settings. The answers provided by the experts are depicted in a sunburst diagram in Figure 3.

Figure 3: Sunburst diagram showing the areas of challenges for digitalization in work-related settings, as indicated by 8 remote experts. DS: digital solutions; DP: data protection; IT: information technology.

Part 2: Examination setting with remote supervision

Gained examination data

The mean IMT ratio of the carotid arteries was 1.092 (SD 0.1), and the mean diameter ratio was 1.06 (SD 0.062). The mean IMT ratio of the femoral arteries was 1.032 (SD, 0.112), and the mean diameter ratio was 1.001 (SD 0.112). The median of the OSAUS score of the participants was rated at 24.75 (Q1: 23.875; Q3: 25; IQR 1.125) and the mean modified AMIAUD score was 25 (Q1: 24.25; Q3: 25; IQR 0.75), with an interclass correlation coefficient of 0.84 for both raters.

Examiners´ experience evaluation

During the evaluation of physicians, all stated that they used several social media in their daily lives and had already used videos to acquire professional techniques (mean agreement 4.75/5). The physician participants considered obtaining video-based knowledge to be practicable in a multitude of capacities. Specifically, the physicians mentioned that it could be used in equipment instruction (n=5), surgical environments (n=4) and emergency rooms (n=2), or further training on examination techniques (n=1). When asked about the advantages or disadvantages of obtaining knowledge via social media, the participants' responses were generally positive. They approved that these resources are constantly available, practical, and easily accessible. This enables learning from home or on the road, regardless of location, and repetition of information is easily possible. However, there are some disadvantages. The physician participants mentioned the lack of opportunity for follow-up questions and, in some cases, unclear transparency of the scientific quality. In response to questions about the advantages and disadvantages of using head-mounted AR devices, the participants stated that it would be advantageous for remote experts to collaborate. This could lead to a gain in knowledge with better technical actions. Furthermore, easy handling and fast data transfer were cited. In contrast, the risk of technical malfunction (especially when *relying* on external help) and the need to learn the handling (eg, head position) were mentioned as disadvantages.

The other Likert-scale evaluation results concerning the video-based transmission of knowledge, the use of the app- and mobile phone-based ultrasound technique, and the practicability and acceptance of the AR device are shown in Figure 4.

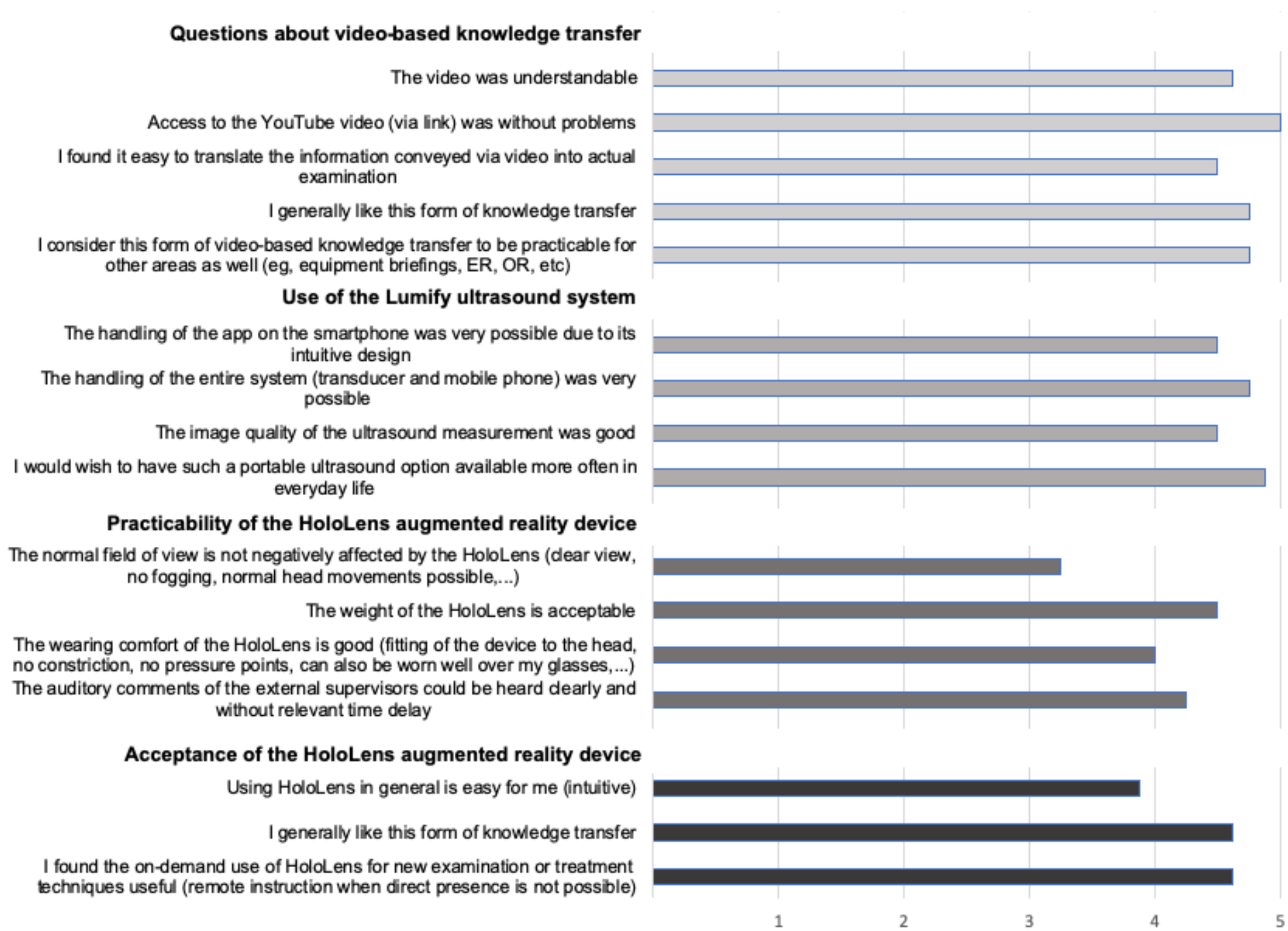

Figure 4: Answers to questions about the video-based transmission of knowledge, the use of the Lumify ultrasound system, and the practicability and acceptance of the augmented reality device HoloLens (n=8 participants; 5-point Likert scale from 1 fully disagree to 5 fully agree). ER: emergency room; OR: operation room.

4.3.5. Discussion

Principal findings

Bridging distances between academic institutions and investigators to enhance scientific collaboration has always been highly important for many research projects [1]. Owing to the COVID-19 pandemic, the need to reduce travel and physical contact has reached levels not seen in nearly 100 years [11]. Digital features, such as social media, have already been shown to be sufficient in enhancing scientific exchange and communication [12]. AR technology and its associated devices can positively enhance collaborations across large distances, but the full potential of this technology is not realized, although it is very promising [10].

In this study, fulfilling the aims and hypotheses, remote experts could sufficiently connect to and actively participate in a simulated exercise science examination scenario by collecting the experts´ opinions concerning the techniques used. Furthermore, it is possible that different physicians could perform the given ultrasound examination while being remotely supervised by the AR device in a multicenter international collaboration structure.

Both the experts and the examining physicians showed a high preference for the remote setting using social media and procedural connection modalities via Microsoft Teams. Social media had already been established as a firm tool in the scientific community before the COVID-19 pandemic [12]. Examples of this have been shown when learning about movement techniques in sports and exercise science [28], instructions on investigations [25], and data literacy skills [29]. All these features experienced a boost in the last months of the COVID-19 pandemic when the use of digital communication, digital conferencing, and digital remote working conditions became normal [30].

In addition, the participating physicians shared high ratings regarding the use, practicability, and acceptance of the technologies, although they were not remarkably familiar with the mobile ultrasound device. This was accompanied by a good evaluation of the investigation system and its devices. It seems to have potential as a smart digital transmission feature for ultrasound examinations [31].

AR was rated, in general, as highly positive by both experts and examiners with its previously described potential to establish scientific- and work-related contacts between remote participants in real time and across large distances, providing expert support and exchange, thus enabling international collaborations [10]. In scientific study settings, AR could also benefit from independent and objective supervision by integrating different experts internationally into a rater team, as performed in this study.

The participants saw the potential for AR in sports science and sports medicine first in training and education, which can be supported by the authors' experiences, for example, in the field of anatomy [21]. Not explicitly mentioned was that the interactivity of AR might make learning more engaging, interesting, and efficient than pure textbooks [32]. Another interesting suggested approach, especially in the field of sports science, could be to link AR with computed tomography or magnetic resonance imaging data to project these data onto moving people, which could support analyses of movement patterns or pathologies and the development of therapies [33]. In general, AR-based human tracking and its analysis seem to be well suited for sports or exercises that depend on form, movement, and technique.

Remote experts and participating physicians stated that good supervision could be possible with AR. Clinical examples show that supervision via AR is possible in surgical settings [10] and that inexperienced users can achieve similar operative results after AR-supervised training compared with other users with on-site training [34].

This study revealed the relevant technical and organizational challenges to be considered. We showed that, with a working internet connection, well-functioning live connections to examinations using AR devices could easily be possible. A decisive point for future projects would be to determine in advance bandwidths or other internet connection conditions, which might pose transmission problems [27].

Remotely coordinating the schedules of subjects, investigators, and supervisors proved to be difficult. In larger-scale collaborations, multiple meetings should be made available, with significant time frames between each session and optional alternative dates to accommodate all of those involved.

Despite the potential of the described setting, there is a learning curve with this technique in the current form. Users will benefit most after becoming familiar with the devices. The method used in this study involves simultaneously handling the mobile *touchpad* for ultrasound measurements and using a head-mounted AR device. For the latter, the mere weight of the device must be anticipated, among other issues. For example, the way the virtual program appears in the user´s vision is optimal when looking directly forward through the device. The user must anticipate the radius of the camera of the device in relation to the user´s own field of view. Therefore, excessive eye and head movements are discouraged. This aspect has already been described as relevant in the surgical context [35].

The scores used in this study have already been published before [25,26]. Although the quality of the measurements was not the focus, a high correlation was found among the supervisors. Owing to the high rating scores observed, perhaps the ultrasound task was not very challenging for the participating physicians. In addition, this could suggest that there was less need for supervision and auditory comments. Consequently, this might have had an impact on the examiners' evaluation, although they were asked not only for subjective but also objective answers. It can also be discussed whether AR technology is the only practical choice in this particular setting. Perhaps a head-mounted camera and speaker/microphone could be a sufficient alternative.

However, the chosen study design was intended to serve as an example of the overall practical use of AR devices in an international sports science or medical collaboration setting. Changes in the design according to the scientific requirements and intensified use of AR options will have to be considered for other settings.

Regarding limitations, this study should be viewed as a first step in investigating the feasibility of such technology and techniques because of the small number of participants. In addition, the chosen study design had a stable examination setting with no necessary body movements required by the examiners, allowing for good viewing. This could differ in other study designs or real-life scenarios, such as a dynamic setting where numerous and quick body or head movements of an examiner or physician will be necessary (eg, surgical interventions and field research). Furthermore, the long axis of the arteries was used for IMT measurement. However, in future studies, it might be considered that there are fewer influencing factors when performing the measurements on the short axis. Finally, AR options such as showing pictures, videos, and 3D animations (eg, videos in the field of view of an examiner) have not been fully used in this approach.

As there is a lack of larger prospective randomized trials in sports science and medicine that can clearly demonstrate the benefits of AR's practical applications, the aspects mentioned above and the use of a larger cohort should be considered in future studies.

Conclusions

This study showed that the described techniques involving social media video distribution in advance, followed by an examination performed with a head-mounted AR device, can be effectively used in a long-distance international collaboration setting. A stable and sufficient internet connection will always be decisive. To optimize international collaboration, especially during the COVID-19 pandemic, this kind of remote support offers advantages such as bridging distances, shortening travel times, providing real-time interaction, and potentially enhancing objectivity in data collection by including remote experts in the study setting. Significant challenges would be the time needed to set up such technical settings, user training, and digital coordination of all participants.

4.3.6. References

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5. General Discussion

Digitalization and social media play an increasingly important role in exercise sciences and the health sector (10, 14). It was the aim of this PhD thesis to establish a model for an international multi-center study in clinical exercise sciences with social media as e-learning distributor for an examination technique among young peer scientists, using an ultrasound-based arterial measurement setting within three different studies. The first one examined the use of social media and e-learning among exercise science students at six European universities (120). The third study explored the possibility of instructing skilled and not-skilled health personnel via a video transmitted by the social media app "WhatsApp" about ultrasound-guided examination techniques (121). Finally, the pilot version of an international exercise science project was launched with the use of an augmented reality device for remote supervision of ultrasound examinations (55).

Below, key aspects of this thesis are discussed and practical implications for future work together with limiting factors are pointed out, combined with an outlook into future research and the educational potential in the field covered in this thesis.

5.1. Social media and e-learning in knowledge distribution

The first study of this PhD thesis was able to show that young students in the field of Sport and Exercise Science already showed a high affinity for social media and, to a certain extent, also for their use in each student's studies (120). Forms of e-learning also have to be considered to be widely established. Similar results were found in the other two studies among doctors, nursing personnel and engineers who are already active members of the workforce (55, 121). It can generally be assumed that members of the current generations of students and professionals show a high affinity for digital media. A fact that has also been demonstrated in recent studies (81, 85, 122). In the studies conducted here as well as in other studies, a possible bias in the responses may be anticipated depending on whether the participation was voluntary or not.

While, generally speaking, e-learning and social media are already used in teaching and for research communication, it must also be seen that not all forms of social media or e-learning can be used equally for every purpose and that fancy trends and hypes are created in teaching research that cannot necessarily be maintained in everyday academic life (123). For example, the use of Instagram and Twitter has been described in individual studies (122), whereas the use of YouTube videos and channels are foreseeably more useful in many settings, especially when teaching movements and procedures (81).

In private communication, messenger apps such as WhatsApp are widely used and are positively propagated in the field of research and clinics (79, 85). The positive acceptance was confirmed in the context of the first study of this PhD thesis (120), which led to WhatsApp being successfully used in combination with a video as a form of knowledge transfer. This was evaluated as a very positive experience in the context of the 2nd study (121). A video seemed to be the most suitable medium for the purpose of this thesis, although other digital learning tools such as audiovisual podcasts could be used depending on the need (124).

In the course of the second study, however, questions arose about the security of the data transmitted through WhatsApp. This would be specifically relevant when using athlete/patient-related information. In studies 2 and 3, a video was used as the form of knowledge transfer and the social media app was switched from WhatsApp to a link-accessible YouTube channel (55, 121). This was done in part to address data security/privacy concerns - even though the used video was anonymous, potential non-anonymity of future research videos should be addressed and therefore the provider under discussion, WhatsApp, needed to be replaced. Other messenger apps could be used instead (e.g. Siilo, Trillian) but this may invoke cost or at least yet another app on the participant's phone (125). Therefore, it was decided to use the social media platform YouTube, which was regarded positively by students as proven in the first study (120). Among other things, YouTube offers password protection for shared content, which means that non-anonymous videos could be distributed among a defined group of recipients.

5.2. The clinical experimental setting

Ultrasound examination of vessels was the choice for the experimental clinical science setting for the social media-supported and, most recently, remotely supervised implementation of an intervention in potential athletes or subjects in studies 2 and 3 (55, 121). Primarily because cardiovascular diseases are considered a major cause of health impairments and deaths worldwide (102). It had already been shown that an investigation of the alteration of vessels in athletes by sport-specific stress may offer important insights for the understanding of pathology etiologies, but also for the prevention and therapy approaches for the normal population (6, 24, 97). Alternatively, in terms of relevant systemic diseases, sports pathologies from the musculoskeletal field, such as injuries of the rotator cuff, injuries in the shoulder, the Achilles´ tendon, or back disorders, could have been chosen (126). Due to the focus of the PhD thesis on the investigation of the transmission methods and materials of processes, no complex setting with, for example, the use of treadmill tests and apparative and laboratory blood analysis investigations or also long-term experiments with the investigation of the influence of certain training methods on physical adaptation processes was chosen, as in other studies (97, 127). Instead, ultrasound examination of arterial vessels was used as methodology and, with the vessel diameter and intima-media thickness, proven basic parameters were established during the examination (128). Here, there is certainly the potential in the future for an expansion to include other measurement parameters, like the vascular stiffness to name but one example(97).

A procedure that has generally been little researched in the experimental as well as in the clinical exercise environment is the ultrasound-supported collection of findings by means of mobile ultrasound devices (129). In addition to the detection of life-threatening injuries, such as abdominal hemorrhage after traffic accidents, scenarios are also conceivable in which other pathologies are collected by examiners on site and - whether for specialized clinical diagnosis or for comparison in the context of study approaches - are transmitted by remote live internet transmission to specified supervisors (130).

The following paragraph further discusses the potential of digital support for bi- and multi-center study approaches.

5.3. Remote augmented reality collaboration

Collaborative work involving the participation of different research groups has so far been determined solely by detailed study protocols (25). In addition, coordination occurred through travel or face-to-face meetings (18). In the context of manual or instrumental subject testing, live on-site briefings by staff from the participating institutions on the required techniques may also be necessary. In addition to increasing the objectifiability of results, the inclusion of multiple centers may also be helpful especially, for example, when studying small populations of athletes in sports science, but also to include larger cohorts of patients in clinical trials (23). An extension of the instructional possibilities can be achieved by digital media. Here, videos have the advantage that they can convey audiovisual correlations to the viewers in the temporal course of the sequence movements or techniques (81). For delivery, classic options such as e-mails are usually not very well suited due to the size of the files. Social media offer a high potential due to their high acceptance among students - as proven in study 1 (120) - but also among healthcare professionals and scientists (29, 85). An effective knowledge transfer through videos has already been described for the instruction of practical activities, such as the installation of chest tubes (131). In study 2 of this thesis, it was shown that video instruction sent through a social media app can be used to effectively teach tasks to non-experienced investigators (121), which may also be important for younger exercise science researchers in research studies (132).

However, as the problem remained that even though receiving videos can already significantly improve comprehension, still no direct control or influence by the sending instructors was even remotely possible. Possible solutions could be live video broadcasts, where observers can watch a performance directly (133). Apart from additional setups or internet connections, however, the viewing angle would also be different here, which can make the view difficult in some situations (e.g. during interventions) due to the examiner's hands lying in the viewing axis, for example. Here, head-mounted cameras could be the solution (134), though the lack of interactivity remains problematic.

This can be addressed through augmented reality (50, 66). With the use of head-mounted devices, external persons can not only take the view of the respective investigator or agent, but also communicate with him beyond audio commentary – such as projecting lines or symbols in the investigator's field of vision or showing images or videos (55). In practice, this may be useful in surgical settings by showing organs (135), among other things, but also in sports settings by tracking joint angles during athletes' movements (136). In study 3 of this thesis, an AR head-mounted device was used to show that external supervisors could also connect from distant locations (55). In addition, the study also demonstrated the practicality of remote live supervision of examination procedures. The findings from the studies in this overall paper (55, 120, 121) are of high value as an example of new forms of multi-center study implementation and will be discussed in terms of their practical implications, limitations and future perspectives below.

5.4. Practical implications

The objective of the present thesis was initially based on the changing working conditions in international research and practice in the field of exercise sciences due to the advancing digitalization. Over the course of the thesis, additional relevant effects emerged in the context of the COVID-19 pandemic, which will foreseeably be paramount for research in the future (1, 94, 96). The relevance of the chosen research approach has been significantly strengthened in the course of the implementation of restrictions due to the COVID-19 pandemic (89). Already at the beginning, there was a tendency in science towards increasing globalization and convergence of different national and international research institutions (18). With the establishment of common scientific standards and the adapted implementation of certain procedures, this made it possible to conduct multi-center studies, which, in turn, were able to significantly improve the evidence of the research results (23, 25).

This includes the need for direct live controls and coordination. Live controls and support by external experts may be particularly important in research with the need for objectivity and neutrality in the collection of results that are intended to generate relevant evidence for future practical statements. Especially this possibility of live controls has hardly been achievable objectively in multi-center study approaches so far (25). Thus, the ways explored here are an important step in using AR technologies for corresponding support. Even beyond the research framework set here, digital communication with universally used and established social media approaches will be crucial in the future. Many studies have shown that in recent years social media and tools generally used in everyday life have also found a high level of acceptance and use in the research environment and should therefore also be researched and introduced here as part of objective approaches (2, 49, 52). New technologies that enable better scientific exchange, especially against the backdrop of the pandemic, will also be crucial in the future. When planning studies with new digital technologies, like AR, it will be important that teams will be trained before in the practical handling to support the acceptance by easing the use of those new technologies.

Especially when using the latest digital approaches and technologies, users need to be aware of the costs associated when it comes to recommendations for possible wide-spread and even international implementation of certain tools. Such costs may be quite significant, e.g., for AR instruments (like the HoloLens of Microsoft Inc. used in study 3) or corresponding programs (e.g. Microsoft Teams), since institutions, regions or even countries with less financial resources could be left behind in research and development of new techniques more easily (137). An objective distribution or awarding of money will also have to be taken into account for areas and countries with less financial resources.

Hence, research on possible solutions, such as cellphone based AR technologies, will be necessary.

5.5. Limitations and future scientific perspectives

The limitations of the individual papers have already been specifically addressed in the respective publications.

Especially concerning the data of the surveyed students in the first project, by the time of writing this doctoral thesis it has been almost 5 years since the time this data had been collected. Consequently, the opinions and behavior of the participants may have changed. It should be repeated such as similar large-scale studies in the United States (138). Just like the broad and fast changing field of digitalization, its potential and use in exercise sciences is continuously adapting (14). It is recommended to repeat the students´ evaluation to keep a “hand on the pulse of time” during and after the COVID-19 pandemic similar to, e.g., the ECAR studies (138). It would also be interesting to compare overviews over the current curricula offered at European universities – and institutions worldwide – to work out “best practice” examples for this field.

For the overall thesis, it must be noted that the number of participants included especially in study 2 and 3 was too small to make a sustainable general statement. However, it was the goal of this PhD thesis to enable statements about the feasibility of the chosen methods and that was accomplished.

While initially a larger number of athletes was supposed to participate in more centers in study 3, the COVID-19 pandemic called for these plans to be adapted taking into consideration the necessary higher protection of potential athlete study participants and not to risk the exposure to infection through contact. However, this may be explored in the future with larger-scaled prospective trials.

The clinically mimicked setting in Studies 2 and 3 with its ultrasound examination of vascular structures was not very complex and is not comparable to other laboratory experiments in the field of exercise and sports science, such as stress tests for athletes with more complex computer analyses (52, 127). This may also be addressed in the future. However, for the purpose of this thesis, it was more appropriate to choose this setting in order to investigate the general suitability of the digital approach chosen.

The inhomogeneity of the professional profiles of the respective participants with sports students in study 1, physicians and nursing staff in study 2 and finally engineers and physicians in study 3 can also be viewed critically (55, 120, 121). For the contents and statements of the study, it shall, nevertheless, be considered sufficient, since the population of students in the exercise science field was interviewed regarding their interests, later the aspect was addressed whether one has to be a specialist to be adequately instructed by videos and finally the remote connection with augmented reality interactivity itself was in the focus and not the investigating persons themselves.

For the future, it also seems to be necessary to implement **knowledge and skill trainings with digital tools**, programs and concepts into sport science education to build digital competencies in exercise scientists. Sport science and health care professionals need to learn as early as during their studies how to integrate digital tools in to their professional life – for the sake of professional athletes, but also lay sportsmen and -women and, in medical settings, also patients.

Thus, the instruction in digital competencies should be included into curricular programs. Focusing on main topics of digitalization, like the ones mentioned in the introductory literature overview in chapters 2.2 and 2.3, competencies can be built either longitudinally integrating the topic into existing teaching offers of a curriculum or by adding single specialized modules (139) – here, it will most likely be only a question of time, till whole study tracks will be developed, combining exercise science with data science.

National and international laws – like the EU general data protection regulation – have to be taken into consideration when dealing with digital approaches with impact on patients´ or athletes´ personal health data (140). Hence, topics like law, data protection, economics, but also ethics will have to be interdisciplinarily united to form a new mindset among the professionals of the future.

Especially in sports and clinical exercise sciences, the integration of new digital technologies like social media, augmented or virtual realties, but also intelligent garments and analyzation of data by artificial intelligence algorithms with generation of new evidences for therapies and everyday lifestyle will be decisive for the health of all people.

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Authors´ Contributions

The here presented thesis was designed as a cumulative dissertation. Within this project, three scientific articles had been prepared, submitted to peer-reviewed journals, and accepted for publication. Following the local doctoral degree regulations (§ 7 (4), sentence No. 2), relevant contributions to these articles from the respective co-authors were acknowledged and finally confirmed by each co-author:

Name	Code	Affiliations	Signature
David Alexander Back	DAB	1. Bundeswehr Hospital Berlin, Berlin, Germany 2. Charité - Universitätsmedizin Berlin, Berlin, Germany	
Martin Bartsch	MB	Charité – Universitätsmedizin Berlin, Berlin	
Klaus Bonaventura	KB	1. University of Potsdam, Potsdam, Germany 2. Ernst von Bergmann Hospital, Potsdam, Germany.	
Alberto Dolci	AD	University of Westminster, London, United Kingdom	
Fabio Galetta	FG	University of Pisa, Pisa, Italy	
Michael Hughes	MH	Cardiff Metropolitan University, Cardiff, United Kingdom	

Patrick Kahle	PK	Kerckhoff-Klinik GmbH Bad Nauheim, Bad Nauheim, Germany	
Luca Labianca	LL	S. Andrea Hospital, Sapienza University of Rome, Rome, Italy	
Jimmy B Lawrence	JBL	Mercer County Community College, West Windsor, NJ, United States	
Harm Peters	HP	Charité - Universitätsmedizin Berlin, Berlin, Germany	
Lia Rigamonti	**LR**	**University of Potsdam, Potsdam, Germany**	
Matteo Secchi	MS	Italian Association of Hydrotherapists and Newborn Educators (AIIEN), Rome, Italy	
Ingo Seidelmeier	IS	Bundeswehr University Munich, Munich, Germany	
Claudio Stefanelli	CS	University of Bologna, Rimini, Italy	
Thomas Thouet	TT	1. Charité - Universitätsmedizin Berlin, Berlin, Germany 2. Humboldt University Berlin, Berlin, Germany	CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN Abteilung Sportmedizin OA Dr. med. Thomas Thouet Campus Charité Mitte Philippstr. 13 - Haus 11 | D-10117 Berlin Telefon: +49(0)30 2093 46090 Telefax: +49(0)30 2093 46054

Bernd Wolfarth	BW	1. Charité - Universitätsmedizin Berlin, Berlin, Germany 2. Humboldt University Berlin, Berlin, Germany	CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN Abteilung Sportmedizin Univ.-Prof. Dr. med. Bernd Wolfarth Ärztlicher Leiter Campus Charité Mitte Philippstr. 13 - Haus 11 | D-10115 Berlin Telefon: (030) 2093 46090 Telefax: (030) 2093 46054

Study	Design	Data collection	Data analysis	Interpretation	Manuscript
1	**LR**, DAB	**LR**, AD, FG, CS, MH, MB, IS	**LR**, AD, DAB	**LR**, AD, FG, CS, MH, MB, IS, KB, DAB	**LR**, AD, FG, CS, MH, MB, IS, KB, DAB
2	**LR**, PK, DAB	**LR**, PK, DAB	**LR**	**LR**, PK, HP, BW, TT, KB, DAB	**LR**, PK, HP, BW, TT, KB, DAB
3	**LR**, DAB	**LR**, MS, JBL, LL, DAB	**LR**, MS, JBL, LL, DAB	**LR**, MS, JBL, LL, BW, HP, KB, DAB	**LR**, MS, JBL, LL, BW, HP, KB, DAB

Note: First author is highlighted in bold

Study 1
Rigamonti L, Dolci A, Galetta F, Stefanelli C, Hughes M, Bartsch M, Seidelmeier I, Bonaventura K, Back DA. Social media and e-learning use among European exercise science students. Health Promot Int. 2020;35(3):470-7.

Study 2
Rigamonti L, Kahle P, Peters H, Wolfarth B, Thouet T, Bonaventura K, Back DA. Instructing Ultrasound-guided Examination Techniques Using a Social Media Smartphone App. Int J Sports Med. 2021;42(4):365-70.

Study 3
Rigamonti L, Secchi M, Lawrence JB, Labianca L, Wolfarth B, Peters H, Bonaventura K, Back DA. An Augmented Reality Device for Remote Supervision of Ultrasound Examinations in International Exercise Science Projects: Usability Study. J Med Internet Res. 2021;23(10):e28767.

List of publications

Cumulative Publications of this PhD

Social media and e-learning use among European exercise science students.

Rigamonti L, Dolci A, Galetta F, Stefanelli C, Hughes M, Bartsch M, Seidelmeier I, Bonaventura K, Back DA.

Health Promot Int. 2020 Jun 1;35(3):470-477. doi: 10.1093/heapro/daz046.

Instructing Ultrasound-guided Examination Techniques Using a Social Media Smartphone App.

Rigamonti L, Kahle P, Peters H, Wolfarth B, Thouet T, Bonaventura K, Back DA.

Int J Sports Med. 2021 Apr;42(4):365-370. doi: 10.1055/a-1268-8837.

An Augmented Reality Device for Remote Supervision of Ultrasound Examinations in International Exercise Science Projects: Usability Study.

Rigamonti L, Secchi M, Lawrence JB, Labianca L, Wolfarth B, Peters H, Bonaventura K, Back DA.

J Med Internet Res. 2021 Oct 5;23(10):e28767. doi: 10.2196/28767.

Other publications and scientific work

Reviews

Potentials of Digitalization in Sports Medicine: A Narrative Review.

Rigamonti L, Albrecht UV, Lutter C, Tempel M, Wolfarth B, Back DA; Working Group Digitalisation.

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Case reports

Use of artificial intelligence in sports medicine: a report of 5 fictional cases.

Rigamonti L, Estel K, Gehlen T, Wolfarth B, Lawrence JB, Back DA

BMC Sports Sci Med Rehabil. 2021 Feb 16;13(1):13. doi: 10.1186/s13102-021-00243-x.

Scientific presentations

The impact of digitalization in exercise sciences and sports medicine

Rigamonti L, Albrecht UV, Lutter C, Tempel M, Wolfarth B, Back DA

Exercise science & training conference (GEST19) of the German Society of Sport Science (dvs), 20.-22. February 2019 – Institute of Sports Science, University of Würzburg

Potential of Digitalization in Sports Medicine

Rigamonti L

CME course on Sports Medicine current concepts. Allegheny Health Network, Drexel University School of Medicine, June 17 2021

Appendix

Abbreviations

3D	three-dimensional
AMIAUD	assessment of mobile imparted arterial ultrasound determination
AR	augmented reality
COVID-19	Sars-CoV-2 / severe acute respiratory syndrome coronavirus 2
CT	computer tomography
DM	diameter
DP	data protection
DS	digital solutions
ECAR	EDUCAUSE Center for Analysis and Research
ECG	Electrocardiogram
ER	emergency room
EU	European Union
G	Germany (abbreviation used specifically in study 1)
I	Italy (I) (abbreviation used specifically in study 1)
IMT	intima-media-thickness (IMT)
IQR	Interquartile range
IT	information technology.
km	kilometer
Mbps	Megabits per second
MOOCS	Massive open online courses
MRI	magnetic resonance imaging
Ms	Milliseconds
OR	operation room.
OSAUS	objective structured assessment of ultrasound skills
Q (1/3)	quartile
RCT	randomized controlled trial
SD	Standard deviation
UK	United Kingdom
USA	United States of America
VR	virtual reality
WHO	world health organization

List of Figures

Figures of the main manuscript of the thesis

Figures of Study 1

Figures of Study 2

Figures of Study 3

List of Tables

Tables of the main manuscript of the thesis

Tables of Study 2

Supplements

Supplement 1: Survey questionnaire in its English version without preface and contact data (the Italian and German versions of the document can be asked from the corresponding author).

Survey of Social Media and e-Learning in Sport Science and Sport Medicine

PREFACE AND CONTACT DATA

Part A: Personal data

1. What is your gender?

- ◯ Male
- ◯ Female

2. What is your age?

◯ Below 18 ◯ 18 to 20 ◯ 21 to 25 ◯ 26 to 30 ◯ 31 to 35 ◯ 36 to 40 ◯ 41 to 45 ◯ 46 or older

3. Please enter here the name of your university (e.g. University of London) (If you are currently attending an exchange program at this university - please also specify additionally your home University):

4. Please enter here the name of your degree course (e.g. sport science):

5. Please enter here your current degree program (i.e. "I will reach next" e.g. Bachelor, Master, PhD...):

6. Please enter here the semester in which you are currently enrolled in (e.g. "3" for the third semester of the master studies, if you have indicated so in question number 5 above):

Part B: Social Media Use in Studies

7. How far do you use Facebook for learning purposes in your studies? (Including any kind of information, data or acquisition of knowledge, which is not just of organisatorial nature)

	Yes	No
I use Facebook to contact peer students for study related learning purposes	○	○
I use Facebook to contact teachers for study related learning purposes	○	○
I use Facebook to post knowledge contents (e.g. statements, links, materials)	○	○
I use Facebook to receive knowledge contents (e.g. expert information, links, materials)	○	○
I use Facebook to discuss study related knowledge contents (actively)	○	○
I use Facebook to follow discussions about knowledge contents (passively)	○	○
I would appreciate, if my teachers used Facebook as teaching aid or tool (where appropriate)	○	○
I do not use Facebook (or at least not at all for learning purposes)	○	○

How else do you maybe use Facebook for study related purposes?

8. How far do you use WhatsApp for learning purposes in your studies? (Including any kind of information, data or acquisition of knowledge, which is not just of organisatorial nature)

	Yes	No
I use WhatsApp to contact peer students for study related learning purposes	○	○
I use WhatsApp to contact teachers for study related learning purposes	○	○
I use WhatsApp to post knowledge contents (e.g. statements, links, materials)	○	○
I use WhatsApp to receive knowledge contents (e.g. expert information, links, materials)	○	○
I use WhatsApp to discuss study related knowledge contents (actively)	○	○
I use WhatsApp to follow discussions about knowledge contents (passively)	○	○
I would appreciate, if my teachers used WhatsApp as teaching aid or tool (where appropriate)	○	○
I do not use WhatsApp (or at least not at all for learning purposes)	○	○

How else do you maybe use WhatsApp for study related purposes?

9. How far do you use Twitter for learning purposes in your studies? (Including any kind of information, data or acquisition of knowledge, which is not just of organisatorial nature)

	Yes	No
I use Twitter to contact peer students for study related learning purposes	◯	◯
I use Twitter to contact teachers for study related learning purposes	◯	◯
I use Twitter to post knowledge contents (e.g. statements, links, materials)	◯	◯
I use Twitter to receive knowledge contents (e.g. expert information, links, materials)	◯	◯
I use Twitter to discuss study related knowledge contents (actively)	◯	◯
I use Twitter to follow discussions about knowledge contents (passively)	◯	◯
I would appreciate, if my teachers used Twitter as teaching aid or tool (where appropriate)	◯	◯
I do not use Twitter (or at least not at all for learning purposes)	◯	◯

How else do you maybe use Twitter for study related purposes?

10. How far do you use Google+ for learning purposes in your studies? (Including any kind of information, data or acquisition of knowledge, which is not just of organisatorial nature)

	Yes	No
I use Google+ to contact peer students for study related learning purposes	◯	◯
I use Google+ to contact teachers for study related learning purposes	◯	◯
I use Google+ to post knowledge contents (e.g. statements, links, materials)	◯	◯
I use Google+ to receive knowledge contents (e.g. expert information, links, materials)	◯	◯
I use Google+ to discuss study related knowledge contents (actively)	◯	◯
I use Google+ to follow discussions about knowledge contents (passively)	◯	◯
I would appreciate, if my teachers used Google+ as teaching aid or tool (where appropriate)	◯	◯
I do not use Google+ (or at least not at all for learning purposes)	◯	◯

How else do you maybe use Google+ for study related purposes?

11. How far do you use LinkedIn for learning purposes in your studies? (Including any kind of information, data or acquisition of knowledge, which is not just of organisatorial nature)

	Yes	No
I use LinkedIn to contact peer students for study related learning purposes	◯	◯
I use LinkedIn to contact teachers for study related learning purposes	◯	◯
I use LinkedIn to post knowledge contents (e.g. statements, links, materials)	◯	◯
I use LinkedIn to receive knowledge contents (e.g. expert information, links, materials)	◯	◯
I use LinkedIn to discuss study related knowledge contents (actively)	◯	◯
I use LinkedIn to follow discussions about knowledge contents (passively)	◯	◯
I would appreciate, if my teachers used LinkedIn as teaching aid or tool (where appropriate)	◯	◯
I do not use LinkedIn (or at least not at all for learning purposes)	◯	◯

How else do you maybe use LinkedIn for study related purposes?

12. How far do you use YouTube for learning purposes in your studies? (Including any kind of information, data or acquisition of knowledge, which is not just of organisatorial nature)

	Yes	No
I use YouTube to contact peer students for study related learning purposes	◯	◯
I use YouTube to contact teachers for study related learning purposes	◯	◯
I use YouTube to post knowledge contents (e.g. statements, links, materials)	◯	◯
I use YouTube to receive knowledge contents (e.g. expert information, links, materials)	◯	◯
I use YouTube to discuss study related knowledge contents (actively)	◯	◯
I use YouTube to follow discussions about knowledge contents (passively)	◯	◯
I would appreciate, if my teachers used YouTube as teaching aid or tool (where appropriate)	◯	◯
I do not use YouTube (or at least not at all for learning purposes)	◯	◯

How else do you maybe use YouTube for study related purposes?

13. How far do you use <u>Skype</u> for learning purposes in your studies? (Including any kind of information, data or acquisition of knowledge, which is not just of organisatorial nature)

	Yes	No
I use Skype to contact <u>peer students</u> for study related learning purposes	○	○
I use Skype to contact <u>teachers</u> for study related learning purposes	○	○
I use Skype to <u>post</u> knowledge contents (e.g. statements, links, materials)	○	○
I use Skype to <u>receive</u> knowledge contents (e.g. expert information, links, materials)	○	○
I use Skype to <u>discuss</u> study related knowledge contents (actively)	○	○
I use Skype to <u>follow</u> discussions about knowledge contents (passively)	○	○
I would appreciate, if my teachers used Skype as teaching aid or tool (where appropriate)	○	○
I do not use Skype (or at least not at all for learning purposes)	○	○

How else do you maybe use Skype for study related purposes?

14. How far do you use <u>Instagram</u> for learning purposes in your studies? (Including any kind of information, data or acquisition of knowledge, which is not just of organisatorial nature)

	Yes	No
I use Instagram to contact <u>peer students</u> for study related learning purposes	○	○
I use Instagram to contact <u>teachers</u> for study related learning purposes	○	○
I use Instagram to <u>post</u> knowledge contents (e.g. statements, links, materials)	○	○
I use Instagram to <u>receive</u> knowledge contents (e.g. expert information, links, materials)	○	○
I use Instagram to <u>discuss</u> study related knowledge contents (actively)	○	○
I use Instagram to <u>follow</u> discussions about knowledge contents (passively)	○	○
I would appreciate, if my teachers used Instagram as teaching aid or tool (where appropriate)	○	○
I do not use Instagram (or at least not at all for learning purposes)	○	○

How else do you maybe use Instagram for study related purposes?

Part C: e-Learning in Sport Studies

15. Do you use e-Learning contents (i.e. any kind of online derived learning/teaching/knowledge materials) for your studies?

- ◯ Yes, very often (more than once a week)
- ◯ Yes, often (at least once a week)
- ◯ Yes, sometimes (less than one a week but at least once a month)
- ◯ Yes, but seldom (less than once a month)
- ◯ Never

16. Does your faculty/department/institute have a learning management system (LMS) (e.g. Moodle, Blackboard, ...)?

- ◯ Yes
- ◯ No
- ◯ I don´t know

If yes, what do you use (what do they have to use, respectively) the LMS for?

____

17. Which of the following <u>online sources</u> do you use to acquire knowledge or scientific information for your studies? (multiple choice permitted)

- ☐ Pubmed
- ☐ Cochrane
- ☐ The leaning management system of my university (e.g. moodle, blackboard, ...)
- ☐ Wikipedia
- ☐ YouTube
- ☐ e-Books (open access)
- ☐ e-Books (access via account/library of my university)
- ☐ Online journals (open access)
- ☐ Others (please specify):
- ☐ Online journals (access via account/library of my university)
- ☐ Google scholar
- ☐ Research gate
- ☐ Mendeley
- ☐ Research ID
- ☐ ORCID
- ☐ Academia.edu
- ☐ I do never use e-Learning materials

____

18. Which of the following e-Learning tools do you use to acquire knowledge for your studies:

	Often	Sometimes	Never
Videos of techniques or methods	☐	☐	☐
Videos of lectures or seminars	☐	☐	☐
PowerPoints of lessons (e.g. lectures, seminars) from my own university	☐	☐	☐
PowerPoints of lessons (e.g. lectures, seminars) from other sources	☐	☐	☐
Online Scripts (e.g. PDF) downloaded from my own university	☐	☐	☐
Online Scripts (e.g. PDF) downloaded from other sources	☐	☐	☐
Web pages with texts about study related contexts	☐	☐	☐
Podcasts	☐	☐	☐
Wikis	☐	☐	☐
Blogs	☐	☐	☐
Serious games	☐	☐	☐
Discussion forums	☐	☐	☐
MOOCs (massive open online courses)	☐	☐	☐
e-Books	☐	☐	☐
Scientific electronic articles	☐	☐	☐

Others: Please name here

19. If you use any e-Learning materials, are they offered by your university and/or free accessible online? (all answering options can be chosen)

- ◯ The e-learning materials that I use are offered by my university and the access to them is for free
- ◯ The e-learning materials that I use are not offered by my university and the access to them is for free
- ◯ The e-learning materials that I use are not offered by my university and I have to pay a fee for using them
- ◯ I do not use e-Learning materials

20. I would appreciate, if my university/faculty/department/institute offered more e-learning materials for my studies

- ◯ Yes
- ◯ No
- ◯ If yes, which kind of e-learning materials would you like to have: