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Experience Report

Applicability of motion capture in interdisciplinary research of assistive technology: a report of experience[1]

Aplicabilidade da captura de movimentos na pesquisa interdisciplinar de tecnologia assistiva: um relato de experiência

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Abstract

Introduction: Assistive Technology (AT) is pointed as one of the possible solutions to offer better functionality and quality of life for people with rheumatological diseases. Interdisciplinary projects focused on assessing, indicating, and developing AT are important for advances in research and clinical care. Motion capture, through technological instrumentation, is an innovative theme for providing objective data about the user. Further studies in this area are needed to know the possibilities of applying technological instrumentation in AT research. **Objective:** To describe the applicability of motion capture, using high-tech equipment, in an interdisciplinary AT research for rheumatological patients. **Method:** It is an Experience Report, with a qualitative approach, in which the actions were described using specific technological equipment to motion capture. **Results:** Motion capture was used for three purposes: educational support; usability evaluation of AT resources developed; and support for study groups of occupational therapists to activity analysis. **Conclusion:** In the different actions, the motion capture was used as a complementary resource for activities' analysis performed by occupational therapists, which contributed to the

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indication, development, and evaluation of AT devices and to facilitate the instructions provided in manual and in the guidance groups about Joint Protection. Interdisciplinary work was differentiated for the proper use of equipment.

Keywords: Motion Capture, Interdisciplinary Research, Self-help Devices, Rheumatoid Arthritis, Osteoarthritis.

Resumo

Introdução: A Tecnologia Assistiva (TA) é apontada como uma das soluções para proporcionar uma melhor funcionalidade e qualidade de vida às pessoas com doenças reumatológicas. Projetos interdisciplinares com foco em avaliar, indicar e desenvolver TA são importantes para os avanços na pesquisa e assistência clínica. A captura de movimento, por meio da instrumentação tecnológica, apresenta-se como um tema inovador por fornecer dados objetivos sobre o usuário. Mais estudos nessa área são necessários para conhecer as possibilidades de aplicação da instrumentação tecnológica em pesquisas de TA. **Objetivo:** Descrever a aplicabilidade da captura de movimento, por meio de um equipamento de alta tecnologia, numa pesquisa interdisciplinar de TA para pacientes reumatológicos. **Método:** Trata-se de Relato de Experiência, com uma abordagem qualitativa, no qual foi descrito as ações utilizando um equipamento tecnológico específico para captura de movimentos. **Resultados:** Foi utilizada a captura de movimento com três finalidades: apoio educacional; avaliação de usabilidade de recursos de TA desenvolvidos; e suporte a grupos de estudo de terapeutas ocupacionais para análises de atividades. **Conclusão:** Nas diferentes ações, a captura de movimento funcionou como um recurso complementar para as análises de atividades realizadas pelos terapeutas ocupacionais, o que contribuiu para a indicação, desenvolvimento e avaliação dos dispositivos de TA e para facilitar as orientações dadas no manual e nos grupos de orientação sobre Proteção Articular. O trabalho interdisciplinar foi o diferencial para o uso adequado do equipamento.

Palavras-chave: Captura de Movimento, Pesquisa Interdisciplinar, Tecnologia Assistiva, Artrite Reumatoide, Osteoartrite.

1 Introduction

Assistive Technology (AT) involves any strategy, service, or product that aims to favor people with disabilities or reduced mobility to carry out their activities with maximum independence, contributing to a better quality of life and social inclusion (Brasil, 2009). According to Galvão Filho (2013), in its traditional conception, the development of AT products was competence in the health area; however, due to new technologies, conceptual advances and the rights of social inclusion of People with Disabilities (PwD), the interdisciplinary character of AT becomes increasingly evident, and its approach in different areas of knowledge is encouraged.

Interdisciplinary research focused on evaluating, indicating, and developing assistive products that are fundamental for advances in studies and clinical assistance in this area (Bueno et al., 2016). Health professionals, such as occupational and applied human and technological therapists, such as designers and mechanical engineers, are important in the team for sharing knowledge and promoting better

results (Bersch et al., 2010; Merino et al., 2016; Cook & Polgar, 2014). In the case of research with people with disabilities, health professionals demonstrate a valuable contribution to the data collection and analysis process (Merino et al., 2018). In this context, the occupational therapist intervenes directly in the issues of accessibility and use of technologies for the performance and functionality of the individual, aimed at achieving greater independence in the different contexts in which he is inserted (Marins & Emmel, 2011), and to promote means for preventing deformities, adapting to changes in daily life and maintaining or improving socialization and emotional issues (Almeida et al., 2015).

In the case of interdisciplinary research on AT, technological instrumentation is an innovative and important topic, as it allows for a more reliable and accurate data collection and for obtaining data about the product, including comfort and safety. Technological instrumentation means the use of equipment to obtain objective (quantitative) measurements of the physical, biomechanical and physiological characteristics of individuals (users of the projects), characterizing their needs and movement disorders (Merino et al., 2017). The training of the interdisciplinary team for the use of technological equipment is necessary as the correct use of the technique brings the team closer to the user's real need, which can make the development of the project more efficient (Merino et al., 2018).

Motion capture is part of technological instrumentation and is considered a technique that allows a faster and more accurate measurement of the user, presenting more objective data related to biomechanics, through a continuous assessment of movement (Merino et al., 2018). According to a literature review carried out by Varnier (2019), the use of motion capture, including optical, Kinect, and inertial systems, aimed to improve the process of development, evaluation, and analysis of the project and support the design of new products (Varnier, 2019).

The applicability of motion capture can assist in the development of product designs in AT, based on the investigation of biomechanical parameters, and also can favor more functional results for people with disabilities or limitations (Merino et al., 2016). These parameters correspond to the premises of biomechanics, which involves the study of human movement for the analysis of physical principles, in the function of the anatomical and physiological characteristics of the human body. The four main areas of study for the biomechanical analysis of human movement are kinematics, dynamometry, anthropometry, and electromyography (Amadio & Serrão, 2011; Amadio et al., 1999).

Some people may have a biomechanical impairment that needs a more detailed investigation. Among them, there are those with rheumatic diseases, such as Osteoarthritis (OA) and Rheumatoid Arthritis (RA). This audience can benefit from improved projects, from the perspective of analyzing the activity, on the best way to use AT products since there is a disabling potential inherent in the disease (Latham & Radomski, 2013; Conaghan, 2008).

RA and OA are diseases with a functional impact on people's lives, making daily activities difficult and often painful (Conaghan, 2008). They can cause difficulties in performing activities, such as self-care, home maintenance, among others (Malcus-Johnson et al., 2005). In these cases, Assistive Technology is one of the solutions to improve the quality of life (Clark, 2000; Almeida et al., 2015). This is because AT

products can provide greater joint protection and biomechanical alignment, which minimizes pain, prevents deformities, and favors the functionality of this audience (Beasley, 2012; Almeida et al., 2015). The orthoses and assistive devices are part of the resources of AT (Brasil, 2009) and are frequently indicated for rheumatological patients (Clark, 2000; Almeida et al., 2015).

Joint Protection (JP) is a method developed for rheumatological patients, to apply biomechanical and ergonomic principles during the performance of activities to prevent normal or abnormal forces from increasing joint stress, joint misalignment, and increased pain (Bianchini et al., 2010; Torquetti et al., 2008; Noordhoek & Loschiavo, 2005). Thus, guidance, such as dividing the weight of the object between two hands, using stronger joints whenever possible, maintaining adequate postures, and using the joint in its most stable and functional plane, are among the principles of JP (Almeida et al., 2015). Thus, exploring the applicability of motion capture can optimize and refine the assessment of patients' performance in their activities and improve intervention with the principles of JP.

The use of motion capture by technological resources to obtain more accurate data and with the visualization of movements for more efficient analysis is already a reality in interdisciplinary research in AT (Merino et al., 2016). However, more studies in this area enhance knowledge about the possibilities of applying technological instrumentation (Speck et al., 2016). Deepening the theoretical knowledge and knowing the practical experience of using equipment by different teams can contribute to the data collection phase with more objective results and with a deeper analysis of the results, in AT projects. The proposed article aims to describe the applicability of motion capture, using high-tech equipment, in an interdisciplinary AT research for rheumatological patients.

2 Methods

This is an experience report with a qualitative approach, carried out from January to November 2018, at LabTATO (Laboratory of Assistive Technology and Occupational Therapy) of the Occupational Therapy course at the Federal University of Pernambuco. It involved a phase of the interdisciplinary research project "Health Care for People with Rheumatological Diseases: Development of Assistive Products and Training of Human Resources in Assistive Technology", contemplated in the Public Call FACEPE 10/2017, Research Program for SUS: Shared Management in Health/PPSUS-Pernambuco, CNPq/MS/SES/FACEPE, focusing on product development and strengthening the AT service for people with rheumatological diseases.

The interdisciplinary team included professors, researchers, and collaborators from the occupational therapy course, researchers from LabTATO and ATC (Assistive Technology Center), and the Medicine and Mechanical Engineering courses at the Federal University of Pernambuco (UFPE); researchers from RPDTA (Assistive Technology Research and Development Network - CAPES)/Design Management Center Design (NGD) and Usability Laboratory (LDU) at the Federal University of Santa Catarina (UFSC); researchers from the Mechanics Course at the Federal Institute of Pernambuco (IFPE) and professionals from the Hospital das Clínicas/UFPE. The research was approved by the Ethics Committee

of the Health Sciences Center at UFPE under the CAAE registration: 71269417.0.0000.5208.

The experience was limited to research actions using specific technological equipment to motion capture. The equipment was used through analysis of activities tested with the researchers and as a graphic resource for educational guidance for patients with rheumatological diseases. The team was trained to use the equipment and to identify and analyze the data presented in the software. Four activities were selected (eating, holding a pan, picking up a bucket on the floor, and sweeping) and dynamic analysis of the movement was performed, including all the joints involved in the activity, except the hand joints, which are not captured by the equipment. The use of the equipment did not occur directly with the patient. The data were described, analyzed, and related to the bibliographic references. Research actions were also described to better understand the application of motion capture.

The Activity Analysis technique is a specific process of occupational therapy in which the demands of the activity are identified, including the physical, cognitive, social, and environmental aspects, and understood what body structures, skills, and performance standards are necessary for the individual to perform (Associação Americana de Terapia Ocupacional, 2015).

In this research, the instrument for capturing movement by sensors used was the MVN Link Biomech da Xsens available by NGD/LDU - UFSC. MVN Link Biomech is a high-tech, high-cost inertial motion capture system that can be used with a focus on biomechanical and ergonomic issues facing AT (Varnier, 2019).

MVN Link allows motion capture through 17 inertial sensor modules and has a frequency of 120 Hz, that is, it generates 120 frames per second (Varnier, 2019). The units of inertial measurement are the motion trackers (Motion Tracker - MTx and MTx-L). They must be placed in specific places on the body through straps or inserted inside the equipment's lycra suit (MVN Lycra Suit) (Xsens Technologies, 2012). Through a wireless connection, the generated data is transmitted to a computer that contains the MVN Pro software, allowing the observation, recording, and analysis of movements based on graphs of joint angles, speed, and duration of the movements (Speck et al., 2016; Roetenberg et al., 2013). Figure 1 shows the MVN Link equipment and the inertial sensors used by it, as well as the assembly and fixation of these sensors on the researcher's body. The MVN Pro software interface is also demonstrated during the activity (sweeping) performed by the researcher with the motion capture.

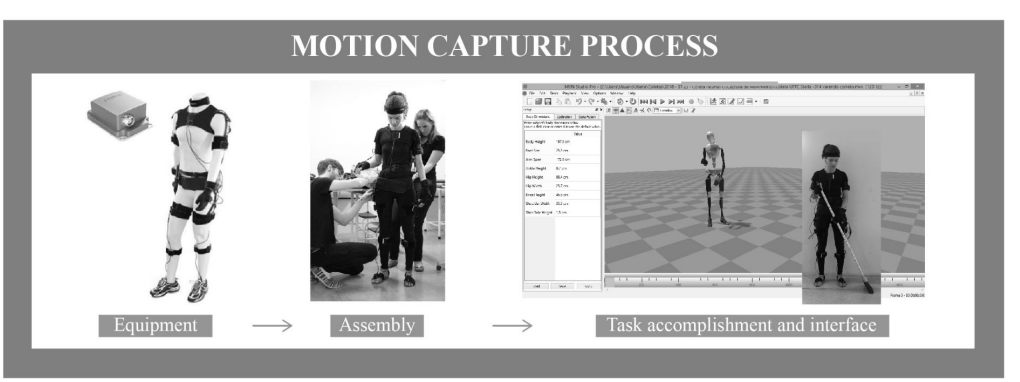

Figure 1. Motion Capture Process. Source: Adapted from Varnier (2019).

Before starting the recording process, MVN Link needed some configuration procedures such as 1) fixing the inertial sensors to the body and connecting the capture cables; 2) definition of user settings (suit) in the software; 3) user configuration (suit setup), which refers to the performance of the procedures to make the capture body compatible with the MVN Link avatar; 4) equipment calibration (Varnier, 2019).

3 Results

Based on the research actions, motion capture had three purposes: Educational Support (adjustments to the guidance manual and helpful resource for the guidance group); Usability assessment of developed AT resources; and assistance to Study Groups for analysis of activities (occupational therapists). Such uses are presented and described in summary form in Figure 2 since the following topics deal with each one in more depth.

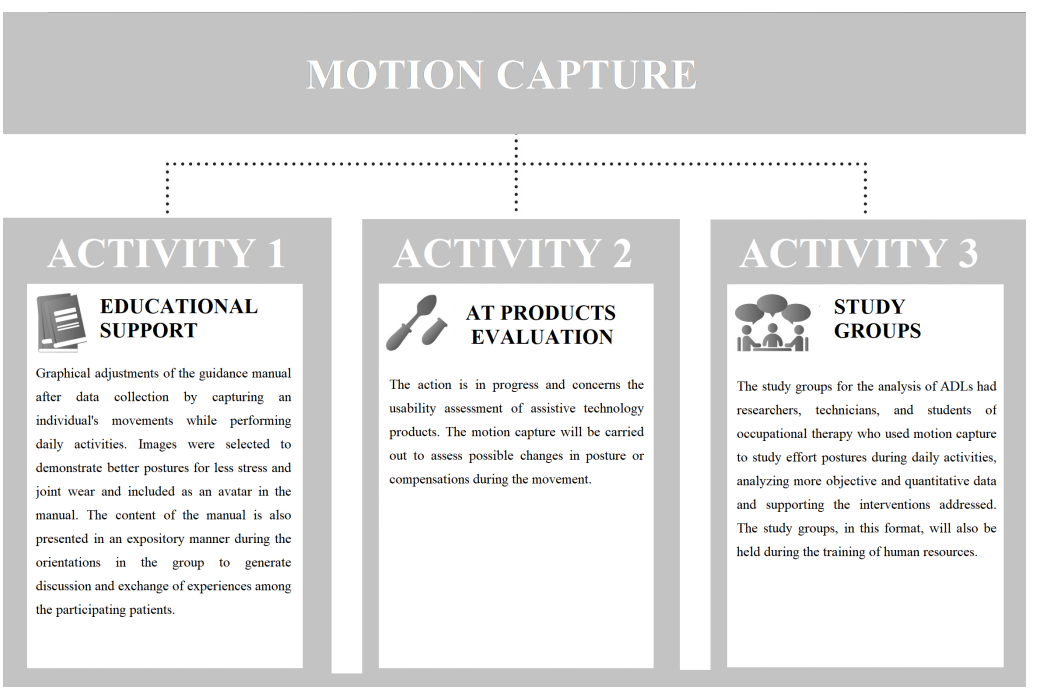

Figure 2. Synthesis of activities performed using Motion Capture. Source: Prepared by the authors.

Motion capture versus educational support

Educational support was based on adjustments in the guidance manual and the graphic images used in the expository presentations of the guidance group.

The guidance manual is a graphic material in booklet format, which addresses issues about what rheumatological diseases such as symptoms, diagnosis, and treatment; performance of the occupational therapist; the principles of joint protection and energy conservation, with a focus on their use during the performance of activities of daily living. The first version of the manual occurred in a master's project (Amaral, 2016); its use was continued in two versions of the extension project "ReumaTO" (Edital Proexc 2015-04 - PIBEX and Edital Proexc 2018-01 -

Continuous Flow); and, finally, it is being used in the research project mentioned in this study. The proposal for the continuous use of the manual allowed its adjustment and improvement. The final objective is that the content of the manual is implemented in the daily routine of patients who access to the booklet.

The contribution of motion capture to the guidance manual came from graphic adjustments. Data were collected based on the motion capture of an individual (volunteer researcher) while performing the following daily activities: eating, holding a pot, picking up a bucket on the floor, and sweeping. Biomechanics and kinesiology aspects, the principles of joint protection and energy conservation, and references in the literature on these aspects were considered.

Based on the team discussion, the most appropriate graphic images were selected to demonstrate the postures that allowed less stress and joint wear daily. Then, the avatar images produced by the instrument software were included in the manual, considered adequate, and applied to the guidance proposed to patients in the rheumatological clinic. Adjustments regarding the manual's graphic design were also made, making it more effective and with improved aesthetics. Figure 3 shows the images of the guidance manual before and after the adjustments.

The guidance group is an action that aims to present the content of the guidance manual, in an expository way, as well as to generate discussion and exchange of experiences among the participating patients. All patients who were included in the research underwent an initial assessment protocol; then they received the guidance manual and participated in the group under the coordination of an occupational therapist on the team. The presentation is made through the projection of slides via data show. Figure 4 shows the images of a guidance group carried out in the research.

Based on the analysis, after using motion capture, the avatar images related the process of joint wear and increased pain due to the inadequate performance of some movements or postures in daily activities, which left easier the assimilation and understanding of the content, as observed in the patients' responses during the groups. Avatar images were also important in the guidance group, used to point out the most painful and most stressful places, and to explain to patients the correct and incorrect movements and postures during activities of daily living.

Motion capture versus evaluation of AT products

The development of low-cost assistive products is one of the objectives of the research project, developing products printed in 3D or with other materials according to the specific needs of the studied population. Thus, four 3D printed products are in the process of evaluating usability and aim to facilitate simple daily activities (ADL) and instrumental activities, such as: peeling food, using a cell phone, opening covers, using a universal adapter, and others. Some products were developed with materials such as PVC and thermoplastic, such as a brush with an extended handle for the bath and an adapted hairbrush, both for an individualized case.

The usability evaluation of the products is an action that is being carried out. In this step, the equipment to capture motion will be used on the patient, who must perform the indicated activities with and without the assistive product, and it is expected to observe changes in posture or compensations during the movement.

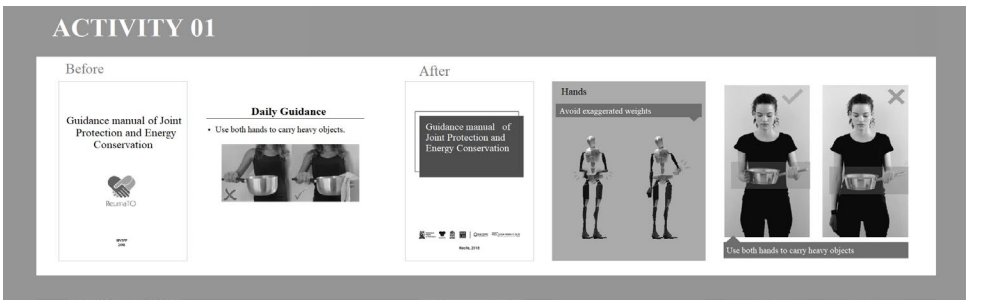

Figure 3. Guidance Manual initial version and updated version. Source: LabTATO Collection, 2018.

Figure 4. Guidance group. Source: LabTATO Collection, 2018.

Motion capture versus study groups - occupational therapists

The use of motion capture in this action involved an in-depth study for the effort postures during daily activities, relating the biomechanical aspects identified with data reported in the literature. The study groups for the analysis of the ADL had researchers, technicians, and students of occupational therapy, who used the high-tech instrument to analyze objective and quantitative data and to base the interventions addressed. Figure 5 shows the images from the MVN Pro software (avatar, graphics, and data), during the performance of a daily activity (holding a pan) performed by the researcher with the motion capture instrument and, also, the team performing the activity analysis. The analyzes of the activities carried out via study groups were responsible for the educational support actions and for the indication of the assistive products developed.

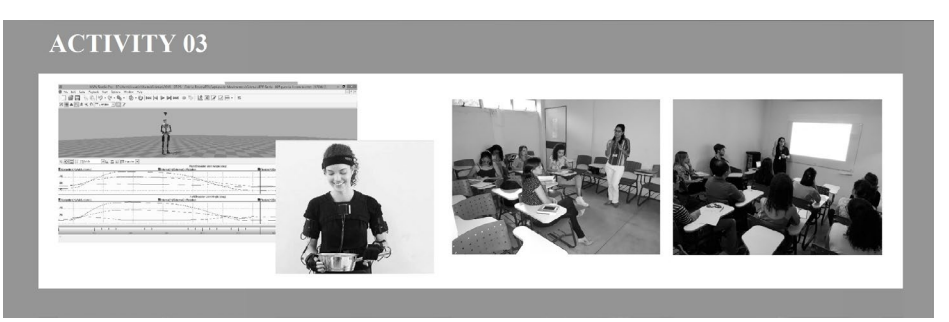

Figure 5. Analysis of ADL with the instrument for motion capture and study group discussing the analysis of the activity. Source: LabTATO Collection, 2018.

4 Discussion

The use of technological instrumentation in interdisciplinary research in the AT area shows an innovative theme by enabling more precise data and more specific analyzes of the products and cases studied. In this study, motion capture was used in 3 possibilities: educational support, evaluation of AT products, and study groups to discuss cases related to the analysis of activities by the team's occupational therapists. Other AT studies have also used motion capture, such as: in Speck et al. (2016), whose images of a patient were captured during the march to develop a stabilizing knee orthosis; in the study by Merino et al. (2018), two patients were analyzed from the motion capture to assess and develop orthoses for lower limbs; and in the study by Prim et al. (2016) with users of the transtibial prosthesis, whose motion capture was used for detailed observation of limitations in the static balance of amputee patients.

We observed in the studies previously mentioned that motion capture was used for specific purposes, such as collecting data to develop the product (orthoses) and, in the latter case, to assess the balance of a patient with a prosthesis. In this research, its usage varied, using motion capture as a complementary resource in the analysis of activities of daily living by occupational therapists and as educational support material, favoring the guidance given to the patient.

The use of motion capture as educational support proved to be interesting since the implementation of Joint Protection and Energy Conservation programs are part of the rehabilitation treatment of these patients (Bianchini et al., 2010; Almeida et al., 2015). The use of guidance manuals is a strategy often used to instruct people with chronic illnesses due to the need to change their lifestyle. The production of the manual must adapt the format to the people and the context, for greater assimilation of the proposed content. The graphic adjustments based on the motion capture allowed a more precise and clear appearance of the postures that should not be performed daily by patients.

The guidance groups are important in this context since they work on issues such as welcoming, socializing, exchanging experiences, and developing the learning of self-care and the principles of education, important for coping with chronic health conditions (Moe et al., 2013; Tavares et al., 2012). Thus, relating the data obtained by the equipment to the principles of joint protection and energy conservation allowed better visualization of the performance of the individuals' activities, in the explanatory presentations of the guidance groups.

The final stage of the research is to evaluate the assistive products developed in this study. It is intended to use motion capture to assess the individual's posture and the quality of the movement using the assistive product and without its use, during the performance of a certain activity. Observing possible changes or improving the individual's posture will enable them to make a relationship with the effectiveness of AT, as well as make adjustments, if necessary. Literature review carried out to identify the use of motion capture in product development found that the instrument facilitates the survey of patients' capabilities and limitations, contributing to the evaluation and analysis of products and improving the development of projects (Varnier & Merino, 2018).

In the last decades, studies have been carried out to evaluate the efficacy of AT products, concerning ADL assist devices and upper limb orthoses, in the treatment of patients with OA and RA, obtaining positive results (Clark, 2000; Gomes Carreira et al., 2010; Kjeken et al., 2011; Beasley, 2012; Amaral et al., 2018). The purpose of indicating orthoses and assistive devices for this audience is to minimize wear and maintain joint alignment, prevent deformities, minimize pain, and favor function (Clark, 2000; Beasley, 2012; Almeida et al., 2015). Based on a clinical trial conducted, Amaral et al. (2018) reported that the use of assistive devices improves the occupational performance of individuals with hand osteoarthritis. A recent bibliographic review highlights that the use of orthosis for patients with rheumatoid arthritis provides benefits in skills of manual dexterity, strength gain in grip, and pain relief (Silva & Massa, 2015). In the aforementioned studies, motion capture was not used to assess outcomes and devices, which demonstrates that it is still little known or used in health research.

Motion capture was also used to contribute to the analysis of activities carried out in the discussion of cases, which was characterized as an action of the research. Activity analysis is a technique that involves the assessment of physical, cognitive, social, and environmental aspects, which allows the occupational therapist to propose treatments and indicate resources, as is the case with AT (Cook & Polgar, 2014; Associação Americana de Terapia Ocupacional, 2015). The motion capture through the identification of quantitative variables such as amplitude, speed, and duration of the movement (Speck et al., 2016) may complement the analysis of the activity performed by the occupational therapist in his clinical practice.

The use of technological instrumentation of motion capture had its use in this research from the work in an interdisciplinary team, which allowed the practical use of the equipment and more detailed analysis through the exchange of knowledge between the professionals of the team, occupational therapists, mechanical designers, and engineers. Studies reported that the use of this type of technology requires the support of interdisciplinary knowledge and, especially, in the case of people with disabilities, the presence of health professionals is relevant (Merino et al., 2018; Speck et al., 2016).

In addition to motion capture, other instruments such as dynamometer, electromyography, and thermographic camera are being used in scientific research in the AT area as a way of collecting data on a given situation and analyzing the requirements for product development (Merino et al., 2016, 2018; Speck et al., 2016). The use of systematic collection protocols is also useful and promising in these processes (Speck et al., 2016). The result of a master's thesis was the creation of a protocol for the use of motion capture (Xsens), intended to act as a guide for data collection, assist the team during this procedure and facilitate the replicability of scientific research (Varnier, 2019).

This interdisciplinary research in AT and applied to the people with rheumatological diseases was an opportunity to use motion capture and observe the contributions of technological instrumentation in this area. The experience of this research brought motion capture as a complementary resource to the activity analysis technique, performed by occupational therapists. However, the lack of the motion capture of the joints of the hands was a limitation of the equipment.

Teamwork was differential for the proper use of equipment, identification, and analysis of software information, after capturing images and applying data in the practice of activity analysis, which suggests that motion capture has great potential to be explored. We need to carry out more specific studies with technological instrumentation in interdisciplinary research in AT, both for the people with rheumatological diseases and for other clinics.

5 Conclusion

Based on the study, we identified 3 research actions in which motion capture was used, using the Xsens equipment: educational support (adjustments to the guidance manual and helpful resource for the guidance group); evaluation of the usability of AT resources; and study groups for activity analysis (occupational therapists). In the different actions, motion capture worked as an additional resource for the analysis of activities carried out by occupational therapists. This contributed to the indication, development, and evaluation of AT devices and to facilitate the visualization of the guidance given in the manual and the guidance groups in the care of people with rheumatological diseases.

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