

RESEARCH ARTICLE

Robotics as a Form of Non Surgical Complementary Osteoarthritis Treatment

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Abstract

Osteoarthritis, a widespread joint disease that engenders considerable disability among a large proportion of older adults in all parts of the world is a major costly social and fiscal public health concern. While largely incurable, it is shown that a variety of carefully designed conservative non invasive interventions may however, influence the disease process quite favourably. However, whether certain advances in technology and less emphasis on non pharmacologic and non surgical health programs and others can be obviated by non human methods is not well clarified. This mini review primarily strove to uncover any favourable advances in this regard in the context of artificial intelligence that may independently or collectively address the needs of older adults with osteoarthritis who are poor surgical or drug candidates. Using **PUBMED, PubMed Central** and **Google Scholar** data bases, an extensive scan covering current discussions and research on osteoarthritis, robots, and robotics shows a sizeable percentage of older adults who suffer from multiple adverse osteoarthritis health complications including musculoskeletal, cognitive, macro and micro tissue disturbances, depression and plus possible neurological and inflammatory manifestations even if they are receiving standard care, may receive some benefit from carefully selected robotically oriented support approaches. Ethical challenges, as well as patient preferences, and know how, plus overall efficacy in face of this complex disease remain to be uncovered.

Keywords: Complimentary and Alternative Medicine, Management, Older Adults, Osteoarthritis, Robots, Robotics

Introduction

Over the past few decades, technological advances have made it possible for non humans and machines to perform multiple tasks that may help to reduce health provider costs and burdens, while fostering the health and well being of many needy citizens, especially those 65 years and older who may suffer one or more chronic health conditions, but who often do not adhere to treatment protocols, or may not have unlimited health services access or support systems.¹ To help the older adult cope and reduce the health care burden, current discussions are focusing on the possible use of various information and communication technologies, and robots that may help older adults to follow healthy lifestyles more ably.

In this mini scoping review we examine how robots or robotics other than those industrial applications that are shown efficient especially at repetitive tasks, can be harnessed to foster human interactions and/or assist in the rehabilitation and health maintenance of older adults.² In particular, the discourse highlights how robots could be applied to improve elder care in the home, including helping older adults suffering from osteoarthritis of one or more joints to apply therapies needed to maintain health as well as helping to receive services and products related to their overall wellbeing.³ This approach was deemed of both high interest and importance to examine in light of the increasing needs of high numbers of aging adults suffering from disabling osteoarthritis joint disease who may face health services cuts, delays, and where surgery or drug treatments are often risky or contra indicated. In addition, since research advocated to advance biological osteoarthritis remediation and others await years of study,⁴ and the disease is commonly progressive and may spread from one joint to involve others, does the role of artificial intelligence that is emerging as a powerful diagnostic and surgical tool for this disease indicate that this technology may also afford this population multiple health additional benefits that can be readily mobilized through the use of robotics.⁵

To this end the **PUBMED**, **PubMedCentral**, and **Google Scholar** data bases housing data published between January 1 2010–July 15 2023 were examined using key words, *complementary and alternative medicine*, *robotics*, and *osteoarthritis*. Although some work has been implemented to systematically review the research in this realm from the standpoint of robot assisted joint surgery and diagnosis, very few applications in other realms of osteoarthritis care appear to prevail, thus a manual search for references was also undertaken.

Since data on the current topic of interest was quite scarce and largely limited to the use of robots in guiding surgical based osteoarthritis procedures or proposed therapies, only a small number of publications met criteria for inclusion in this brief. Moreover, robotic applications in long term care settings that are used did not align with the current aim of determining any role for robotic approaches in the context of older adult population

living in the community or in environments that have service related challenges that remain of major concern. The aim was to begin to address if in the context of global aging and declining revenues and increased costs of care, a case for advancing a more widespread role for robotics in osteoarthritis community based care appears promising, notwithstanding the current lack of evidence and possible misuse that might unfold by relying excessively on non human rehabilitation approaches in venues at any distance from key health centers.

The paper is hence introductory and exploratory at best, albeit an integrated one that briefly discusses the extent of osteoarthritis challenges that may be faced by many older adult populations, and the possible introduction of adjunctive support by robotic approaches to reduce disability, dependence and mobility challenges, while possibly fostering an active or proactive high quality state of living, rather than a passive and a subdued life experience.

Articles were selected by the author if they:

- 1) showed some updated osteoarthritis information;
- 2) alluded to robotic assistive device approaches that could be applied in the home to foster independence in the face of disability or aging or both, even if they were not based on solid research. No adaptive robotic applications for surgery, drug discovery, or pathology investigations were included and no formal evaluation of the studies retrieved was attempted in this emergent undeveloped realm. The focus was also on naturopathic or complementary approaches rather than drug or surgical interventions and that in the future might help many who are low income, in immense pain, have poor vision, mobility, or manual dexterity, and are frail. It does not discuss well known technical assistive devices, for example wheel chairs, or wearable devices such as braces and orthotics or studies that discussed other health issues, were not published in English or did not match the current home based theme or population of interest. For further discussion perspectives, the article by Dahl⁶ may be highly informative.

Current Noteworthy Findings

When examining the current literature detailing osteoarthritis, even if not all data bases were consulted, there is clearly no shortage of data to support a need for advancements in all realms of osteoarthritis care, including novel approaches, and those that may reduce care burdens and costs, while fostering greater independence and an improved ability to age actively or as desired. Indeed, many articles detailing osteoarthritis and published in the **PUBMED** data base for over 100 years, including 4856 items posted in the first six months of 2023 largely support this need. Indeed, although not apparently lethal, its presence persists globally, and is an immense universal disabler of

older adults and can induce high levels of morbidity and possible premature mortality rates if narcotic medications are indicated. Accompanied by multiple biochemical and cellular alterations in the synovial joint tissues and others, which often induces intractable bouts of pain a need exists for pursuing all avenues of possible promise for reducing osteoarthritis dysfunction in the older population. Alternately, poorly managed osteoarthritis is likely to lead to more rapid progressive histological and structural changes of one or more joints, where impairments in physical function are common.

Currently, despite immense efforts in the past few decades to advance osteoarthritis care, many pressing needs of multiple adults affected by osteoarthritis remain or may remain unaddressed, however. This may be due to a more handicapped population due to multiple COVID-19 impacts, the prevailing lack or unavailability of previously available services, service providers who are overwhelmed or retiring or do not grasp the totality of the disease or offer standard albeit limited treatment options to their clients. As well, more adults than in prior years are wanting to age in place rather than long term care units and desire to as well as need to be active, but may be too functionally impaired in diverse ways without some form of day to day technological support.

The mythology that the condition is inevitable and one where nothing can be done except surgery may indeed make it very challenging to mitigate through the use of diverse self management strategies even if the provider is an advocate for this.⁴ Moreover, the failure to detect any joint change early on and to act early on to reverse this may foster a host of declining unanticipated social and economic opportunities, but providers may fail to appreciate the relevance of these more intangible social and emotional correlates of the disease. The persistent reliance on drugs may also worsen rather than improve the condition, or prove fatal, for example, long term opioid usage to counter pain. In other cases, local joint injections designed to alleviate pain, may not provide long term relief, or prevent an older adult from overusing their injected now temporarily pain free joint, and exposing it to further damage or actually damaging the cartilage tissue, such as corticosteroids. While surgery may be indicated for a highly disabled older adult at some point, this may not be without risk and may yet require considerable after care, and may be contra indicated for many osteoarthritis older patients.

It is possible though that various insightful carefully construed approaches that can address one or more adverse osteoarthritis dimensions may help to reduce the substantial societal costs of this debilitating chronic condition among many home bound older adult populations. This idea, while not entirely novel, appears highly salient to consider in light of the rapid ageing of societies and increasingly prevalent obese populations—a disease linked strongly with the causes of some forms of osteoarthritis— that are expected to become much more

prevalent in the future than in previous decades. At the same time, aging adults and others are subject to considerable reductions in health services, and assistance from family members who have to work may be limited. This is especially problematic among multiple aging osteoarthritis sufferers who may exhibit muscle weakness, a high levels of falls risk and injury, and where exercise⁷ that can possibly afford some mitigation of the immense osteoarthritis burden, even if surgery is eventually required, may be very challenging to accomplish without support and guidance.

As well, other aspects of disease appropriate self-management, such as the need to protect the joints affected, and to maintain a healthy weight, behaviors that are often strongly indicated,^{8,9} may not be possible without some ongoing support mechanisms. Moreover, even if drugs are needed, some form of assistance in this regard is often indicated, especially in light of possible multiple chronic health conditions, such as diabetes. Even if surgery is indicated, wait lists may currently be very lengthy and thus day to day suffering may well be increased and activity limitations and pathology worsened, and illness behaviors heightened, if no adjunctive assistance is forthcoming on a daily or routine basis as is indicated.

Many therapeutic devices have consequently been used in this regard for many years, but may yet be further supplemented by thoughtful use of more current and/or future robotic tools especially if tailored to the older adult's needs and personal situation.^{10,11} This may include assistance that does not prevent autonomy,¹¹ but improves function and life quality. It may involve assistance with detecting and addressing emergency situations, locating objects, assisting mobility and memory recall, and assisting with daily living performances.¹⁰

In this context, it is possible medically oriented or adapted robots may have the potential to significantly enhance the humans' ability to perform important tasks—in this current case of osteoarthritis management, and in terms of home based care¹² and in consideration of the costs of care,¹³ or by simply helping an older handicapped adult with osteoarthritis who wants to reside in the community without unduly compromising their degree of independence. Theoretically, osteoarthritis associated features that may be mitigated via various robotic applications include multiple overlapping forms of handicap and disability as listed below.

However, even if the ability to avert or ameliorate osteoarthritis and its immense challenges outlined above is increasingly dependent on surgery and risky medications, it is yet possible to conjecture that personal robots as well as more updated robotic technologies could play a fundamental role in promoting the efficiency and efficacy of managing this health condition and others.¹² For example, a hybrid robot–cloud approach could be used to support seniors with osteoarthritis



Figure 1. Summary of several key symptoms encountered by many older osteoarthritis cases that might heighten existing health challenges and limit independent living in those 65 years or older.^{2,4,14–20}

who want to reside in their own homes though the delivery of both direct as well as personalized medical services.¹² They could provide important reminders, robotic forms of joint protection, and pain relief thus promoting the older adult's ability to pursue a state of independent living and high life of quality, especially in the presence of several additional chronic diseases, and if the older adult does not have ready access to needed health services.

As discussed by Huang²¹ intelligent physical robots, including mechanoid, humanoid, android, and animalistic robots, have been widely employed in hospitals, nursing homes, mental health care centers, laboratories, and surgical units for some time, thus the science base for this approach is quite robust. Although largely an untapped resource in the realm of home health care, especially for the older impaired adult, it is possible one or more of these various categories of robotics or their adaptations may yet be quite relevant for purposes of fostering osteoarthritis home based management regardless of limited services availability. While more research is needed, it appears this approach if studied further and modified and applied accordingly for the individual in question could arguably raise the sufferer's life quality and degree of independence to a desired degree without a formal or informal caregiver or reduce the needs for costly care services. In some cases, even among those who are not technological savvy, these benefits may include, but are not limited to, a variety of ergonomic adaptations and

usages that might greatly assist in mitigating otherwise advancing dependency and disability as enumerated below

1. Assessments, health neural and muscle monitoring, and health and weight loss decision making.^{22–27}
2. Gait capacity, reciprocal locomotor training, weight bearing stability, joint protection, and balance enhancement.^{17,28–30}
3. Pain relief via robotic acupuncture treatment,^{31,32} or an on line pain coping skills training intervention³³ that can be accessed on demand or when needed, or a new robotic knee brace for knee osteoarthritis.³⁴
4. Education and trans-active care for instructing exercise, while improving muscle strength and joint range of motion,³⁵ safety and quality of care³⁶ adherence to medication and exercise regimens.³⁷

In addition to providing one possible practical and cost savings solution that can assist older disabled adults living at home with robots in the role of a coach, providing motivation for healthy living, diet and exercise, plus healthcare support, while possibly assisting with housework and daily chores.⁶ Other benefits may include the increasing ability of robots of various modes or forms of delivery and task specific features to streamline health delivery and provide help as needed in performing one or more needed daily tasks, improve the effectiveness of desired outcomes, and/or the client's feeling or increased feeling of autonomy, versus despair.^{6,38}

As well, carefully programmed and personalized intelligent robots may prove helpful for advancing psychological health directly or via an automated mobile phone messaging delivery system.³⁹ They may be useful in addition for offsetting declines in physical as well as cognitive capacity, while fostering the ability of the client to effectively manage their health condition and possible desired level of independence⁴⁰ and joint protection.³⁰ Moreover, they may help in generating positive emotions and in promoting multi sensorial interactions that can be harnessed to offset noxious stimuli¹⁴ and obviate the need for narcotics or need for assisted living long term care accommodations. The use of various forms of robotic pets⁴¹ and personalized robots may also positively impact the cognitive status of frail elders and others quite markedly and impactfully.⁶

Alternatively, the use of socially assistive robots, a new tool, may help slow the disease progression, while improving the overall health and quality of life in the elderly. At the same time, while many argue against the use of non human interventions to foster later life care, research currently shows older adults to be relatively open-minded about these opportunities, at least some aspects of these, and intend to use them the future, especially for addressing physical assistive functions.⁴² Companion robots are especially identified as being of possible social support and may be designed to foster or enable various health affirming activities such as dancing, singing, storytelling, educational, visual travel or news-reporting functions.⁴³

Daily care robots as well as others similarly show high promise in the context of improving elder care, especially in providing and delivering contactless access to medication support, medication prompts, health and wellbeing directives.^{44,45} In addition, ergonomic robots¹⁹ that are able to lift overweight clients, compensate for declines in muscle power, and/or those adapted to apply an exoskeleton approach that can serve as a mobility assistive device for use in the home may enhance the scope of desired health provider based actions. That is, they may collectively or independently have the potential to safely enhance an osteoarthritis patient's ability to rise from a chair, as well as reducing stair climbing time and aiding their functional abilities, while mitigating excess joint stresses, joint impacts and injury, and pain.⁶

To alleviate the most common health conditions that often accompany and exacerbate osteoarthritis, as well as unsustainable health care demands, various robotic derived devices used in neural rehabilitation, hypertension, or diabetes control situations or others are likely to be valuable. In addition, those designed to provide empathy, compassion and a sense of motivation and accommodate interactive social communications¹ may similarly be useful for fostering overall self-care ability and desire.^{6,43}

They may also help in alleviating adverse mechanical and other stresses on providers, plus unwanted mechanical stresses on already damaged osteoarthritis joints such as the upper limb and hand joints^{46,47} or lower limbs. They may also have the capacity to improve the scope of assessments,⁴⁸⁻⁵⁰ the ability to adapt directives as indicated and foster optimal and essential weight control efforts.^{6,25,51} Their use in medication management and safe regular tailored dispensing of this, plus blood pressure monitoring—important for many older osteoarthritis adults, also appears highly promising, as often, even if related health affirming behaviors are indicated in educational materials, not all clients may be able to carry out these recommendations without instrumental or motivational support.^{6,45,52}

In sum, although more research is clearly indicated, as per Gassert and Dietz,⁴⁹ robot-assisted therapy as well as other diverse forms of robotic support can potentially provide a number of advantages over conventional osteoarthritis treatment approaches. These may include the use of a personalized form of adaptable support, a device that can accommodate varying environmental health influences, while having the potential to increase or decrease therapy intensity and dose as indicated and in line with a patient's self-management skills. Devices that are carefully construed to account for the individual's emotional perspectives and personal goals, knowledge and self-confidence are especially indicated for isolated and physically challenged older adults. Also favored are promising robotic strategies that can reduce provider centered burdens as well as those of family members or caregivers. Indeed, while largely developmental and conceptual in this regard, it is foreseeable that carefully designed and tested rehabilitation robots, while not ideal for all, may prove in time to be an ideal or generally positive means of intervening in osteoarthritis care without drugs or surgery. In addition to having the potential to complement conventional therapy approaches commonly conducted in clinics or community centers, careful home based robotic applications may possibly help to reduce osteoarthritis associated adverse disease manifestations, and immense suffering, along with excess office visits plus added care and social costs. Hence, despite their obvious ethical, cost, and delivery shortcomings in the realm of home health care support, the idea that robotic applications may not be desired or efficacious for sustaining osteoarthritis self management and other interventions among older community dwelling adults, seems to be outweighed by their far and wide reaching potential and promise for advancing multiple sustainable health practices and life quality.

Discussion

Osteoarthritis, the most prevalent joint disorder and a leading cause of disability and suffering plus an increasing source of

substantial societal costs in all aging societies remains a major public health concern despite years of study. In the absence of any cure, not only does more need to be done currently to mitigate its enormous disabling impacts, but also in the future and in light of its association with increasing age as well as obesity—that are both becoming more prevalent societal features. At the same time, many predict an inability to support the aging population with osteoarthritis effectively and in a sustainable manner due to health services shortages, a health scenario where traditional services will be overwhelmed or in short supply, and public health budgets stretched to the limit. This serious chronic disease is also not only a physical one, but is accompanied by varying emotional, social, and mental health correlates that remain very challenging to attenuate or treat, especially if drugs and surgery are contra indicated.

Indeed, even if the affected individual lives with an able bodied person, many who could provide some form of support may have limited time, and skills needed to intervene in any of the above disease features on a consistent basis.

In addition to the well established role of a variety of health providers from medicine as well as alternative medicine fields and others, the recent emergence of smart homes and intelligent physical robots based on artificial intelligence principles have however, shed some light on an array of promising adjunctive robotic support approaches, already shown to offer modest—dramatic changes in many aspects of home health care.^{21,53} Indeed, in osteoarthritis care, end stage disease surgery and diagnoses are almost totally reliant on the skills afforded by artificial intelligence. While not a topic of this brief, previous research that has examined the use of intelligent physical robots in the health care context of older adults and those with health challenges from different perspectives, which was the current topic relative to osteoarthritis home care, shows some potentially favorable opportunities. These may be applied in conjunction with other established approaches, as well as post—operatively, as indicated.

Although more support for this idea is needed, as per Ganesan⁵⁴ in addition to emerging technologies such as the internet of things, sensors, cloud computing, wireless communication technologies, assistive robotics appear to have the potential to support an elderly persons ability to live safely and independently in their living environment and participate in their daily and community activities, even in the face of disability.⁵⁵ Indeed, it is possible to envision that if employed optimally, and consistently, wearable soft—robotic devices and others can potentially help at least some disabled older osteoarthritis clients to maintain their physical, mental, and general health capacity, plus a high quality of life if this is their desire.⁴⁷

Hence, even if there are arguments against the use of robotics in the case of older adults, and counter support for their use is still quite limited, and possibly fails to report on devices that are already in use or are yet to emerge, it appears safe to say robotic devices and approaches should not be overlooked as adjunctive support mechanisms along with other interventions designed to afford greater living opportunities to older adults with mild—moderate joint disease.⁵⁶ The attributes of osteoarthritis that may be reduced to some degree are affective distress, health literacy challenges, safety issues, excess joint loading, physical disability, poor exercise participation rates, loneliness, and pain.

Ethical issues however, must be addressed, including—privacy and autonomy issues. Robotic tools should not be defective, or confusing to use, and should be developed and tested before use by reputable groups. In addition, a skilled professional is still needed to assess, guide, and provide support for developing a practical and cost effective evidence based personalized care plan, and if this includes robotic elements be enacted in line with the client's preferences, goals, personal assets, and abilities. In addition to education about the disease, users should be educated about any user related issues, so they can use these safely and confidently, as indicated.^{25,34,55,57}

As per Pearce⁵⁶ robotics currently available to assist older healthy people and people with disabilities to remain independent and to monitor their safety and social connectedness have been tested largely in laboratories and hospital clinics, not necessarily in the home, and the homes of an older adult with one or more painful joints, thus more research is needed here to affirm a role in the home for the many promising and emerging smart technology strategies that are rapidly evolving. Robinson⁴⁰ suggest that to maximize the utility of personalized robots and pets, more focus could be placed on developing preventative interventions, multifunctional robots, greater educational content and motivational aspects of robotic appearance and interaction style, rather than only on rehabilitation aspects alone. Additional attention to costs to ensure applications can be taken up where desired¹³ and can be employed ethically⁵⁸ and with no undue safety concern has also been highlighted.³⁴ It also appears that the ability of automated robotic sensors that can capture day to day or periodic disease variability or severity indicators, as well as identify activity limitations or improvements thereof, could greatly advance the ability of the provider to tailor their treatment plans accordingly and to avoid delays in expediting help. They may similarly prompt the patient to adjust their activities and behaviors without the need for human assistance, or identify those who need advanced care⁵⁹ and may yet hold immense promise for enhancing possible future tissue specific intervention targets and signaling pathways, for example via robotic mediated acupuncture, unloader bracing, and exercise approaches.^{4,30,31,60–62} Those that are reliable, age—friendly,

ensure privacy is protected, account for digital literacy status and that can meet the diverse needs and preferences, of the older individual in question as well as those of the caregiver, but avoid overly relying on these systems, are strongly indicated as well.^{63,64} Ultimately, it is conceivable, disease manifestations may stabilize more readily in the context of robotic care than in the absence of care, and immense societal benefits may accrue if these devices in general can reduce the need for services, as well as the need to undertake any undesired move from their homes, to those with that are less desired and costly to society, such as long term care facilities.¹¹

Conclusion

A current overview of painful disabling osteoarthritis, and the possible use of various robotic devices to enable its home based management in later life, while largely exploratory, leads us to conclude:

- Osteoarthritis remains a widespread and incurable highly disabling chronic health condition.
- While not all older adults suffering from osteoarthritis may desire to receive some form of support from one or more robots, home care robots may help reduce associated physical and emotional correlates and a worse than desired outcome and prognosis all things considered, while enhancing self-care opportunities.
- Applied in an insightful manner they may relieve some degree of distress, as well as carer burden and costs.
- Those who are highly disabled, but want to remain in their own homes might be especially assisted.
- As well, the need for long term care services and possible surgery may be reduced.
- More extensive research, both qualitative and quantitative in this sphere is strongly indicated and may prove insightful with far reaching benefits.
- Allied health workers should not neglect opportunities to learn about the potential of robotics and their multidimensional properties and assistive and ergonomic attributes and be able to assess and educate their older clients with osteoarthritis ably and cogently in this regard.

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Conflicts of Interest

None

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