Initial Development of a Linked Data Infrastructure for Strength Training Information: Linked Fitness Training (LiFT) Ontology

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1. Background

In recent surveys of the fitness industry, online, virtual, and on-demand training have emerged as top trends, joining body weight and free weight strength training in the top 10 overall fitness trends worldwide, along with mobile apps and personal training included in the top 20 (Thompson, 2022). While information on strength training exercises and workout routines is available on fitness-related websites, as Instagram posts and YouTube videos, and in online exercise “libraries” and “directories,” it is also dispersed throughout various interfaces with varying types of information organization and different levels of resource description. Within these resources, there are both overlaps and gaps in information due the emphasis on differing aspects of strength training exercises depending on their perspective (i.e., resources for bodybuilding, powerlifting, calisthenics, etc.). These resources lack a common infrastructure to aggregate and link, and thus collectively leverage, this heterogenous data on strength training. Creation of a linked data infrastructure would enable this wealth of information to be searched across different resources and different subdisciplines to develop integrated strength training plans.

2. Aims

This project aims to create a linked data infrastructure to aggregate web-based resources on strength training information. This infrastructure would be intended to provide a semantic model to support the development of personalized exercise and fitness plans. Potential users of systems supported by the ontology would include people with an interest in strength training from beginners to advanced lifters; fitness instructors developing strength training plans; and those with specialized exercise needs, such as avoidance of activities involving certain muscles, muscle groups, or movements as well as the ability to propose alternative exercise options based on physical requirements or equipment limitations. This semantic infrastructure could then be utilized and/or queried under requisite parameters to assist in retrieval of strength training information and in supplementing development of exercise plans.

The project also has two auxiliary goals. The first goal is to promote interoperability by mapping web resources to classes and properties in relevant biomedical ontologies to bridge online data with existing biological, medical, and exercise-related linked data models. The second goal is to allow semantic annotation of source or provenance information to enable mechanisms of individual user choice to filter and evaluate resources in context (Coladangelo, 2021).

3. Relevant Literature

Increasing attention to fitness training as a body-centered hobby, and thus as a form of serious leisure (Codina et al., 2020), has proved to be a useful lens to conceptualize the investment of skills, knowledge, and experience necessary to encourage adherence to training regimens. Serious leisure has also been coupled with information behavior, finding that serious leisure-based information activities have implications for promoting passionate learning and personal satisfaction (Mansourian, 2021). Feelings of competence and autonomy have been found to be positively correlated to self-determination in exercise, which was further positively related to exercise behavior, attitudes, and physical fitness (Wilson et al., 2003). This suggests that information systems which encourage users to build exercise knowledge and skills could then have a potential effect on helping them to promote their own physical and mental wellbeing.

Serious leisure research has also identified specific information activities common to the successful pursuit of serious leisure activities, such as search and retrieval, information exchange, and instruction (Hartel et al., 2016). Fitness-related information activities and needs vary at different levels of skill and commitment, necessitating support for different types of information behaviors, from passive monitoring and browsing of exercise activities to active seeking and scanning (Hirvonen et al., 2012). Provision of reliable fitness information provided at low cost or reduced barriers to access has been also found to reduce the potential harm of invalid fitness information resources (Jalali, 2020). Knowledge organization systems, such as linked data vocabularies and ontologies, have been posited to play a significant role in reducing uncertainty in support of decision making by facilitating information exchange regarding medical information (Zeng et al., 2020).

Although ontologies have been created for health and wellness needs such as specialized diets (Clunis, 2019; Haussmann et al., 2019), sports information (Zhai & Zhou, 2010), exploratory web searching of exercises (Kotzyba et al., 2015), structured data related to physical activity (Kim et al., 2019), health and exercise advice (Izumi et al., 2006), and nutrition and biomechanics information for Olympic weightlifters (Tumnark et al., 2013; Tumnark, Abreu et al., 2018; Tumnark, Cardoso, et al., 2018), an ontology has not yet been developed for strength training with an emphasis on integrating movements, muscle groups, equipment needs, and exercise plans and routines.

4. Theory and Methods

An instrumental (Tennis, 2012) domain analysis (Hjørland & Albrechtsen, 1995; Hjørland, 2002) of online exercise resources and typical strength training plans was conducted for the purpose of gathering concepts, terms, and relationships toward ontology development. Facet analysis (Hjørland, 2013; Hudon, 2020) guided differentiation of concepts as they occurred in the domain. The Ontology Development 101 methodology (Noy & McGuinness, 2001) was used to guide construction of the ontology, with Protégé software (Musen, 2015). Ontology design through domain analysis was iterative in nature: as more resources were explored and analyzed, classes and properties were refined and revised. Classes and properties were structured in the W3C Web Ontology Language (OWL). Labels were chosen through literary warrant (Barité, 2018) and classes were defined through relevant criteria and relationships with other classes found during analysis. Properties from SKOS and Schema.org were used to map between the LiFT ontology and other ontologies, vocabularies, and web resources.

5. Main Findings and Underlying Work

The resulting LiFT ontology included 30 top level classes, approximately 280 total classes, and 38 properties. Classes included types of exercises and related movements, exercise equipment and equipment components, parts of the body, muscles and muscle groups, components of exercise routines, and types of resources for exercise information published in digital environments.

To support interoperability and reuse, concepts (and their terms) relevant to strength training were manually mapped to corresponding classes in biomedical ontologies available through the BioPortal repository (https://bioportal.bioontology.org/). Mapping to and/or reuse of classes were derived from the Ontology of Physical Exercises (OPE), the Foundational Model of Anatomy (FMA), the Uber Anatomy Ontology (UBERON), the Galen Ontology (GALEN), and the National Cancer Institute Thesaurus (NCIT). To further support interoperability in a web-based environment, Schema.org types (e.g., ExercisePlan and AnatomicalStructure) and related properties were mapped to from the LiFT ontology. Linking to Wikidata items and properties was explored in the context of using Wikidata as a linked data hub to connect to other identifiers.

The LiFT Ontology structured links to related web resources, such as such as webpages with exercise movement descriptions or instructional video demonstrations. This included annotations for source material to ensure transparency and to allow users to review and appraise the source of the information (such as the author of a website or the creator of a video). The resulting linked data infrastructure was able to model and integrate data regarding physical strength training activities, anatomical structures, exercise equipment, and details about exercise plan components (e.g., named exercises, sequences, repetitions, intensities, etc.).

Further refinement, implementation, and user testing will guide future research. After initial development, the ontology will be re-examined and revised in accordance with best practices to meet FAIR (Garijo & Poveda-Villalón, 2020) and 5-star (Vatant, 2012) principles for linked data vocabularies.

6. Relevance to Conference Themes

This research project relates to conference themes regarding health-related KOS in addition to semantic structuring of contextual information to support user choice. It also demonstrates mapping between biomedical ontologies, the Schema.org vocabulary, and the newly developed LiFT ontology to describe and structure strength training exercise plans.

7. References

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