Introduction to the Special Z-Issue in Honor of the 90th Birthday of Vladimir M. Zatsiorsky

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This Special Z-Issue of Motor Control contains papers written by students, trainees, and younger colleagues of Professor Vladimir M. Zatsiorsky, who turns 90 years young in December 2022, and continues being an inspiration for researchers in movement science. The contributions of Vladimir Zatsiorsky to biomechanics, sport science, and motor control are so many and varied that he is rightfully viewed as a classic in all those fields of research. In these brief introductory comments, I will try to focus on the main contributions of Vladimir to motor control, although many of those studies can also be viewed as pertaining to biomechanics.

Most earlier studies by Vladimir were in the fields of biomechanics and sport science. Those early studies culminated in a book Physical Qualities of an Athlete published in 1966 in Russian. This book became a bestseller and was translated into 10 languages. After his emigration to the United States, Vladimir published three volumes (Zatsiorsky, 1998, 2002; Zatsiorsky & Prilutsky, 2012) that have become the go-to sources for researchers in biomechanics and motor control. In addition, he wrote a book on strength training (Zatsiorsky, 1995), which has become his most popular publication if one judges by the number of citations.

I met with Vladimir for the first time in 1976 when I joined the Department of Physiology of the Institute of Physical Culture in Moscow as a junior researcher, and Vladimir was already Chair of the Department of Biomechanics. Our contacts at that time were brief and formal—at seminars, meetings, and in the hallways of the institute. They led, however, to developing close relations with Vladimir’s students including Alexander Aruin who became a very close friend and colleague. Many years later, in the early 1990s, Vladimir left Russia for Canada and the United States, and I invited him to Chicago to present a seminar in the Rush-Presbyterian St. Luke’s Medical Center. We spent a few days together and realized that our views on the field of movement science were rather similar despite the fact that Vladimir worked primarily in the field of biomechanics, and I performed studies of human motor control and movement disorders in neurological patients.

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Vladimir’s interest toward the field of the neural control of movement can be traced back to the mid-1960s when he met Nikolai Bernstein and also developed interactions with the Moscow school of motor control led by Israel Gelfand and Michael Tsetlin. Nevertheless, at our first meeting, Vladimir was rather skeptical toward motor control and expressed his view as: “motor control studies are performed by people who cannot measure properly.” There was indeed a lot of truth in that statement and, even now, neural control variables remain elusive and hard to quantify objectively in real time. Vladimir also told me that, for motor control to become a recognized field of research, it had to have a dedicated journal, a scientific society, and a series of conferences. This was truly inspirational and, over the years, led to the emergence of the journal Motor Control, the International Society of Motor Control, and biennial conferences Progress in Motor Control.

By the mid 1990s, Vladimir worked in the Biomechanics Laboratory of Penn State, and this was a very important factor in my decision to move to Penn State from Chicago. Our first collaboration was based on the idea of Vladimir to initiate studies of finger coordination. This was a very bold step given that, until that time, neither of us had worked on the control of the human hand—arguably, one of the most complicated effectors given its anatomy, mechanics, and muscle organization. I am forever grateful to Vladimir for initiating those studies, which have proven highly important for understanding some of the basic principles of motor control and resulted in well over 150 papers we published together. Those studies also formed the foundation for training a large number of doctoral students and postdocs, starting with Zong-Ming Li, Frederic Danion, and Sheng Li. As a byproduct of our collaboration, Vladimir Zatsiorsky mellowed his attitude to motor control as a legitimate field of movement science. Vladimir served for many years on the Editorial Board of Motor Control as the Section Editor for Biomechanics and contributed to the organization and success of the first of the series of meetings Progress in Motor Control. Here is a very subjective brief list of the most important studies of Vladimir from the point of view of his colleague in the field of motor control.

Studies of Finger Interaction

The very first of those studies introduced a set of indices quantifying independence and interdependence of finger forces, in particular the index of enslaving (Li et al., 1998; Zatsiorsky et al., 2000). Those studies were very important for the introduction of the notion of finger mode, as a variable manipulated by the brain (Danion et al., 2003), which led to a large series of studies exploring finger coordination within the framework of the uncontrolled manifold hypothesis (Scholz & Schöner, 1999; reviewed in Latash, 2008, 2019). In particular, they demonstrated error compensation across fingers (Latash et al., 1998), an insight later formalized within the uncontrolled manifold hypothesis. Those early studies continue being important for exploration of impaired finger coordination in neurological patients (reviewed in Latash & Huang, 2015) and for recent exploration of intramuscle synergies (Madarshahian et al., 2021).
Studies of Prehensile Tasks

Those studies, performed initially by our doctoral student Jae kun Shim (Shim et al., 2003, 2005), explored intertrial variability of individual digit force vectors during static (and, later, dynamic) prehensile actions. They formed the foundation for the concept of a small set of multidigit synergies stabilizing components of the resultant force vector acting on the grasped object (Zatsiorsky & Latash, 2008). Furthermore, they led to the idea of the principle of superposition in human prehension (Zatsiorsky et al., 2004), resembling this principle introduced in robotics (Arimoto et al., 2001). Furthermore, Vladimir’s interest in mathematics culminated in a study using methods of analytical inverse optimization (Terekhov et al., 2010) to account for the observed patterns of digit involvement. In my opinion, this method remains unique and underexplored as a potential tool to study neural strategies of the control of abundant systems.

Studies of Postural Sway

A series of studies with Marcos Duarte—a visiting postdoctoral researcher from Brazil—introduced the idea that spontaneous postural sway represented superposition of two processes termed rambling and trembling (Zatsiorsky & Duarte, 1999, 2000). The former reflected migration of the equilibrium point for the body, an insight very closely related to the idea of movement control with referent spatial coordinates originating from the classical equilibrium-point hypothesis (Feldman, 1966, 1986; reviewed in Feldman, 2015; Latash, 2010, 2019). The latter reflected peripheral mechanisms including the mechanics of peripheral tissues and action of reflex loops. This was the first set of studies extending the idea of control with referent coordinates to whole-body actions.

I would also like to emphasize a few of the ingenious methodological approaches suggested by Vladimir that continue being exceptionally useful in our current studies. These include the so-called “suspension setup” (Shinohara et al., 2003) that allows modifying the point of force application along each finger thus changing the contributions of intrinsic and extrinsic finger flexor muscles. This setup was important, in particular, for showing that typical patterns of finger interaction were primarily of a neural origin, not reflections of the anatomy of multidigit extrinsic hand muscles (Latash et al., 2002). Another ingenious device was the so-called “inverse piano” (Martin et al., 2011). This device allowed applying controlled linear perturbations to individual fingers while recording their forces. Recently, it has proven invaluable in a series of studies of synergies at the level of neural control variables (Ambike et al., 2016).

The small selection of papers in this issue reflects the variety of research interests of Vladimir’s students. The papers include a computational study of biomechanical trajectories using Monte Carlo simulations (Pataky), a study based primarily on tools from biomechanics to explore locomotion in obese persons (Gorniak and Meng), a study on the organization of gait in preparation to stepping over an obstacle (Ambike and coauthors), a study of the effects of startling auditory stimulation on an accurate force production task (Li and coauthors), a study on the role of gravity in the organization of multidigit coordination during a prehensile
task (Park and coauthors), a study of the effects of nerve stimulation during cat locomotion (Prilutsky and coauthors), a paper describing a new tool, “inverse saxophone,” motivated by the “inverse piano” (Varadhan SKM and coauthors), and a review on some of the basic characteristics of biological movements and associated trade-offs among those characteristics (Latash).

All the contributors to this Special Z-Issue wish to express their deep gratitude to Vladimir Zatsiorsky for the great pleasure of working together and learning from one of the great scientists in the field of human movement science. We wish Vladimir many years of happy life filled with interactions with his family and friends.

References


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