

Philippe Malcolm

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H-index: 22, 1744 citations

<https://scholar.google.be/citations?user=Q1XcsrUAAAAJ&hl=en&oi=sra>

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Positions

2017-present Assistant Professor at Department of Biomechanics and Center for Research in Human Movement Variability at the University of Nebraska at Omaha, Biomechanics Research Building

Associated with Harvard University
John A. Paulson School of Engineering and Applied Sciences
and Wyss Institute for Biologically Inspired Engineering

Postdoctoral collaborator with Movement Science Lab at Ghent University
Department of Movement and Sports Sciences

2015-2016 Postdoctoral Research Fellow, Harvard University
John A. Paulson School of Engineering and Applied Sciences
and Wyss Institute for Biologically Inspired Engineering
Role: Biomechanics team-lead in a project on design and development of a soft lower-extremity assistive device
Advisor: Conor J. Walsh

Summer 2013 Visiting Scholar, Carnegie Mellon University
Department of Mechanical Engineering
Project: The influence of push-off timing in a robotic ankle-foot prosthesis on the energetics and mechanics of walking
Advisor: Steven H. Collins

2010-2014 Postdoctoral Assistant, Ghent University
Department of Movement and Sports Sciences
Laboratory of Movement Science
Advisor: Dirk De Clercq

Education

2004-2010 Ph.D., Ghent University
Thesis: Influence of intrinsic and extrinsic determinants on the transition from walking to running.
Advisor: Dirk De Clercq, Committee: Andre Seyfarth, Marc Van Leemputte, Jos Vanrenterghem, Kristiaan D'Aout, Eric Witvrouw, Wim Derave

2002-2003 Second M.Sc., Academic Teaching Training, Ghent University

2000-2002 M.Sc. in Physical Education (Kinesiology), Ghent University,
Grade: magna cum laude

1998-2000 B.Sc. in Physical Education (Kinesiology), Ghent University,
Grade: cum laude

Teaching

2021	Lab methods in biomechanics II
2017-2019	MATLAB for Movement Sciences
2017-2021	Undergraduate biomechanics
2017-2019	Guest lectures for Motor Control I
2013-2014	Honors program in movement science, 1 st and 2 nd year of kinesiology M.Sc.: advanced internship to prepare students for a job as sports scientist or the start of a Ph.D.
2012-2013	Lecturer in individual movement activities 1 st and 2 nd year of kinesiology M.Sc.: coordination of sports and sports didactics courses from 5 teaching assistants on track and field, artistic gymnastics, and swimming.
2008-2011	Movement analysis of fitness training, 1 st year of kinesiology M.Sc.: EMG and isokinetic measurement practicum
2004-2014	Sport-specific movement analysis, 1 st year of kinesiology M.Sc.: demonstration of all measurement methods in sports biomechanics and hands-on projects of each student his sports-coaching specialization
2004-2014	Movement analysis, 3 rd year of kinesiology B.Sc.: practical exercises on gait analysis and lifting ergonomics with treadmill, force plate, video and motion capture
2004-2014	Biomechanics, 2 nd year of kinesiology B.Sc.: practical exercises on ground reaction force measurement and data analysis in Excel

Mentoring and Advising

Present	MSc. advisor of Kayla Kowalczyk and Siena Senatore
Present	PhD. advisor of Alex Dzewaltowski
2018-present	PhD. advisor of Arash M. Gonabadi
2017-2020	PhD. advisor of Prokopios Antonellis (graduated summer 2020)
2017-2018	MSc. advisor of Cory Frederick (graduated summer 2018)
2015	Co-mentor of one design-engineering final project at Harvard University
2010-2015	Co-advisor Ph.D. Breine B.: Initial foot contact patterns in shod running, relationship with speed and impact intensity
2010-2015	Mentor Ph.D.: Galle S.: Ankle-foot exoskeletons, from experimental optimization to practical applications
2011-2015	Advisor of eight M.Sc. theses in kinesiology and one M.Sc. thesis in electromechanical engineering
2013-2015	Mentor of two honors theses
2004-2010	Mentor of seven M.Sc. theses in kinesiology

Student grant support

2020	UNO GRACA for Kayla Kowalczyk and Siena Senatore	\$5000
2019	AMTI ASB travel grant Prokopios Antonellis	\$1000
2019	UNO GRACA Prokopios Antonellis and Arash M. Gonabadi	\$5000
2019	UNO GRACA Arash M. Gonabadi	\$5000
2019	UNO FUSE Taylor Runyan	\$5000
2019	NIH Summer workshop Prokopios Antonellis	
2018	UNO GRACA Prokopios Antonellis	\$5000
2018	OpenSim virtual workshop entry Arash M. Gonabadi	

Publications

Manuscripts as first author (* is equal contribution)

1. **Malcolm, P.**, Galle, S., Van Den Berghe, P., De Clercq, D., 2018. Exoskeleton assistance symmetry matters: Unilateral assistance reduces metabolic cost, but relatively less than bilateral assistance. *J. Neuroeng. Rehabil.* 15. <https://doi.org/10.1186/s12984-018-0381-z>
2. **Malcolm, P.**, Galle, S., Derave, W., de Clercq, D., 2018. Bi-articular knee-ankle-foot exoskeleton produces higher metabolic cost reduction than a weight-matched mono-articular exoskeleton. *Front. Neurosci.* 12.
3. **Malcolm, P.**, Rossi, D. M., Siviyy, C., Lee, S., Quinlivan, B. T., Grimmer, M., and Walsh, C. J. “Continuous Sweep versus Discrete Step Protocols for Studying Effects of Wearable Robot Assistance Magnitude” *Journal of NeuroEngineering and Rehabilitation* 14, no. 1 (2017): 72. doi:10.1186/s12984-017-0278-2
4. **Malcolm, P.**, Lee, S., Crea, S., Siviyy, C., Saucedo, F., Galiana, I., Panizzolo, F. A., Holt, K. G., and Walsh, C. J. “Varying Negative Work Assistance at the Ankle with a Soft Exosuit during Loaded Walking” *Journal of NeuroEngineering and Rehabilitation* 14, no. 1 (2017): 62. doi:10.1186/s12984-017-0267-5
5. **Malcolm, P.**, Galle, S., and Clercq, D. De. “Fast Exoskeleton Optimization” *Science* 356, no. 6344 (2017): 1230–1231. doi:10.1126/science.aan5367
6. Galle, S., **Malcolm, P.***, Collins, S. H., and Clercq, D. De. “Reducing the Metabolic Cost of Walking with an Ankle Exoskeleton: Interaction between Actuation Timing and Power” *Journal of NeuroEngineering and Rehabilitation* 14, no. 1 (2017): 35. doi:10.1186/s12984-017-0235-0
7. **Malcolm, P.**, Quesada, R. E., Caputo, J. M., and Collins, S. H. “The Influence of Push-off Timing in a Robotic Ankle-Foot Prosthesis on the Energetics and Mechanics of Walking” *Journal of NeuroEngineering and Rehabilitation* 12, no. 1 (2015): 21. doi:10.1186/s12984-015-0014-8
8. **Malcolm, P.**, Breine, B., Frederick, E., Cheung, J., and Clercq, D. De. “Correlations between Strike Index and 5,000 and 10,000 M Performance in Male Runners” *Footwear Science* 5, no. S1 (2013): doi:10.1080/19424280.2013.799581
9. **Malcolm, P.**, Derave, W., Galle, S., and Clercq, D. De. “A Simple Exoskeleton That Assists Plantarflexion Can Reduce the Metabolic Cost of Human Walking” *PLoS One* 8, no. 2 (2013): e56137. doi:10.1371/journal.pone.0056137, **+275 citations.**
10. **Malcolm, P.**, Segers, V., Caekenberghe, I. Van, and Clercq, D. De. “Experimental Study of the Influence of the M. Tibialis Anterior on the Walk-to-Run Transition by Means of a Powered Ankle-Foot Exoskeleton.” *Gait & Posture* 29, no. 1 (2009): 6–10. doi:10.1016/j.gaitpost.2008.05.016
11. **Malcolm, P.**, Fiers, P., Segers, V., Caekenberghe, I. Van, Lenoir, M., and Clercq, D. De. “Experimental Study on the Role of the Ankle Push off in the Walk-to-Run Transition by Means of a Powered Ankle-Foot-Exoskeleton” *Gait & Posture* 30, no. 3 (2009): 322–327. doi:10.1016/j.gaitpost.2009.06.002
12. *De Smet, K., **Malcolm, P.**, Lenoir, M., Segers, V., De Clercq, D., “Effects of Optic Flow on Spontaneous Overground Walk-to-Run Transition” *Experimental brain research* 193, no. 4 (2009): 501–8. doi:10.1007/s00221-008-1648-6

Manuscripts as co-author

1. A Mohammadzadeh Gonabadi, P Antonellis, **P Malcolm**, Differences between joint-space and musculoskeletal estimations of metabolic rate time profiles, *PLoS computational biology* 16 (10), e1008280
2. Papachatzis N, **Malcolm P**, Nelson CA, Takahashi KZ. Walking with added mass magnifies salient features of human foot energetics. *Journal of Experimental Biology*. 2020 15;223(12).
3. Gonabadi AM, Antonellis P, **Malcolm P**. A system for simple robotic walking assistance with linear impulses at the center of mass. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*. 2020.
4. Antonellis P, Frederick CM, Gonabadi AM, **Malcolm P**. Modular footwear that partially offsets downhill or uphill grades minimizes the metabolic cost of human walking. *Royal Society open science*. 2020 Feb 5;7(2):191527.
5. Hedrick, E.A., **Malcolm, P.**, Wilken, J.M. and Takahashi, K.Z., 2019. How Prosthetic Ankle Stiffness & Load Carriage Affect Metabolic Energy Expenditure During Walking. *JNER*, 2019
6. Jinsoo Kim, Giuk Lee, Roman Heimgartner, Dheepak Arumukhom Revi, Nikos Karavas, Danielle Louise Ryan Nathanson, Ignacio Galiana, Asa Eckert-Erdheim, Patrick Murphy, David Perry, Nicolas Menard, **Malcolm P**, Conor J. Walsh; Reducing the metabolic rate of walking and running with a versatile, portable soft exosuit. **Science**, 2019.
+ 30 citations
7. B Breine, **P Malcolm**, S Galle, P Fiers, EC Frederick, D De Clercq, Running speed-induced changes in foot contact pattern influence impact loading rate, *European journal of sport science* 19 (6), 774-783 2019
8. M Grimmer, BT Quinlivan, S Lee, **P Malcolm**, DM Rossi, C Siviyy, CJ Walsh, Comparison of the human-exosuit interaction using ankle moment and ankle positive power inspired walking assistance, *Journal of biomechanics* 83, 76-84 2 2019
9. P Antonellis, S Galle, D De Clercq, **P Malcolm**, Altering gait variability with an ankle exoskeleton *PloS one* 13 (10), e0205088 2018.
10. Kim, M., Ding, Y., **Malcolm, P.**, Speeckaert, J., Siviyy, C. J., Walsh, C. J., and Kuindersma, S. "Human-in-the-Loop Bayesian Optimization of Wearable Device Parameters" *PLoS ONE* 12, no. 9 (2017): doi:10.1371/journal.pone.0184054
11. Breine, B., **Malcolm, P.**, Gerlo, J., Frederick, E. C., and Clercq, D. De. "Spatial Distribution of Impact Intensity under the Shoe in Different Foot Strike Patterns" *Footwear Science* 9, (2017): S24–S25. doi:10.1080/19424280.2017.1313901
12. Clercq, D. De, Breine, B., **Malcolm, P.**, Caekenberghe, I. Van, Fiers, P., and Frederick, E. C. "Striking the Ground with a Neutral Ankle Angle Results in Higher Impacts in Distance Running" *Footwear Science* 9, (2017): S31–S32. doi:10.1080/19424280.2017.1313905
13. Lee, G., Kim, J., Panizzolo, F. A., Zhou, Y. M., Baker, L. M., Galiana, I., **Malcolm, P.**, and Walsh, C. J. "Reducing the Metabolic Cost of Running with a Tethered Soft Exosuit" *Sci. Robot* 2, no. 6 (2017): 6708–31. doi:10.1126/scirobotics.aan6708
14. Quinlivan, B. T., Lee, S., **Malcolm, P.**, Rossi, D. M., Grimmer, M., Siviyy, C., Karavas, N., Wagner, D., Asbeck, A., Galiana, I., and Walsh, C. J. "Assistance Magnitude versus Metabolic Cost Reductions for a Tethered Multiarticular Soft Exosuit" *Science Robotics* 2, no. 2 (2017): eaah4416. doi:10.1126/scirobotics.aah4416 **+ 150 citations**
15. Breine, B., **Malcolm, P.**, Segers, V., Gerlo, J., Derie, R., Pataky, T., Frederick, E. C., and Clercq, D. De. "Magnitude and Spatial Distribution of Impact Intensity Under the Foot Relates to Initial Foot Contact Pattern" *J Appl Biomech* (2017): 1–21. doi:10.1123/jab.2016-0206

16. Galle, S., Derave, W., Bossuyt, F., Calders, P., **Malcolm, P.**, and Clercq, D. De. "Exoskeleton Plantarflexion Assistance for Elderly" *Gait and Posture* 52, no. November (2017): 183–188. doi:10.1016/j.gaitpost.2016.11.040
17. Breine, B., **Malcolm, P.**, Caekenberghe, I. Van, Caekenberghe, I. Van, Fiers, P., Frederick, E. C., Clercq, D. De, Frederick, E. C., and Clercq, D. De. "Initial Foot Contact and Related Kinematics Affect Impact Loading Rate in Running" *Journal of Sports Sciences* 35, no. 15 (2017): 1556–1564. doi:10.1080/02640414.2016.1225970
18. Ding, Y., Panizzolo, F. A., Sivi, C. J., **Malcolm, P.**, Galiana, I., Holt, K. G., and Walsh, C. J. "Effect of Timing of Hip Extension Assistance during Loaded Walking with a Soft Exosuit" *Journal of NeuroEngineering and Rehabilitation* 13, no. 1 (2016): 87. doi:10.1186/s12984-016-0196-8
19. Lee, S., Crea, S., Galiana, I., Malcolm, P., Walsh, C. J., Galiana, I., Asbeck, A., Walsh, C. J., **Malcolm, P.**, Walsh, C. J., Galiana, I., Asbeck, A., and Walsh, C. J. "Controlling Negative and Positive Power at the Ankle with a Soft Exosuit" *Proceedings - IEEE International Conference on Robotics and Automation 2016–June*, (2016): 3509–3515. doi:10.1109/ICRA.2016.7487531
20. Breine, B., **Malcolm, P.**, Caekenberghe, I. Van, Fiers, P., and Clercq, D. De. "Kinematic Differences between (A)typical Initial Rearfoot and Midfoot Contact Patterns" *Footwear Science* 7, no. S1 (2015): S102-103.
21. Galle, S., **Malcolm, P.**, Derave, W., and Clercq, D. De. "Uphill Walking with a Simple Exoskeleton: Plantarflexion Assistance Leads to Proximal Adaptations" *Gait and Posture* 41, no. 1 (2015): 246–251. doi:10.1016/j.gaitpost.2014.10.015
22. Galle, S., **Malcolm, P.**, Derave, W., and Clercq, D. De. "Enhancing Performance during Inclined Loaded Walking with a Powered Ankle-foot Exoskeleton" *European Journal of Applied Physiology* 114, no. 11 (2014): 2341–51. doi:10.1007/s00421-014-2955-1
23. Breine, B., **Malcolm, P.**, Frederick, E. C., and Clercq, D. De. "Relationship between Running Speed and Initial Foot Contact Patterns" *Medicine and Science in Sports and Exercise* 46, no. 8 (2014): 1595–603. doi:10.1249/MSS.0000000000000267
24. Caekenberghe, I. Van, **Malcolm, P.**, Segers, V., and Clercq, D. De. "A Gradual Shift in Initial Foot-to-Ground Contact Patterns Depending upon Acceleration" *Footwear Science* 5, no. S1 (2013): S88-89.
25. Galle, S., **Malcolm, P.**, Derave, W., and Clercq, D. De. "Adaptation to Walking with an Exoskeleton That Assists Ankle Extension" *Gait & Posture* 38, no. 3 (2013): 495–499. doi:10.1016/j.gaitpost.2013.01.029

Other publications

1. Arash, M. G., & **Malcolm, P.** Tutorial: Using EduExo to visualize electromechanical delay in m. biceps brachii. American Society of Biomechanics educational repository, 2018.
2. **Malcolm, P.** & De Clercq, D., 2013. Best practice in biomechanics and how it can be used in high performance sport: The longitudinal follow-up during competition of an elite high-jump athlete. In *Managing High Performance Sport*. ISBN-10: 041567199X.
3. **Malcolm, P.**, 2010. Influence of intrinsic and extrinsic determinants on the transition from walking to running. *Ph.D. thesis*, Ghent University. Faculty of Medicine and Health Sciences.
4. De Clercq, D. & **Malcolm, P.**, 2009. Elite sports movement analysis: added value for training programs. *Flemish trainer school*.

Accepted / Under review / In preparation

1. Awad, LN, Conor JW, Malcolm P, Soft wearable robotics. Springer book on Wearable Robotics for Motion Assistance and Rehabilitation. **In press.**
2. Antonellis, P., Gonabadi, A. M., & **Malcolm, P.** Pushing the boundaries of efficient robotic walking assistance forward, by simple timed impulses at the center of mass. Under Review.

Awards

- 2018 Finalist selection for Clinical Translational Research Superstar grant writing competition.
- October 2013 Study of the week, literature update on mailing list sponsored by the International Society of Biomechanics
Study: Adaptation to walking with an exoskeleton that assists ankle extension.
- April 2013 Study of the week, literature update on mailing list sponsored by the International Society of Biomechanics
Study: A simple exoskeleton that assists plantarflexion can reduce the metabolic cost of human walking.
- 2007 Young Investigator Award, International Society of Biomechanics, XXIth Congress, Taipei
Study: A pneumatic ankle-foot-orthosis as a mean to experimentally validate hypotheses about the role of the tibialis anterior in the walk-to-run transition.

Hardware Demonstrations

- 2015 Warrior Web demo: Harvard Soft Exosuit. *DARPA Wait What? A Future Technology Forum*, St. Louis.
- 2014 WALL-X : A semi-Wearable Assistive Lower Leg eXoskeleton for testing effects of ankle assistance. *Dynamic Walking conference*, ETH Zürich.

Invited Presentations

- 2020 Wearable Robotic Conference “A robotic tether can assist more efficiently than a passive tether, but the optimal timing is counterintuitive.” WeRob Madrid
- 2019 Using wearable robots to “feel” metabolic cost and provide simple timed assistance. UNMC Surgery Forum. Omaha
- 2019 Using wearable robots to “feel” metabolic cost and provide simple timed assistance. UNO Biomechanics Seminar Series, Omaha.
- 2019 Assistive mechanisms of (distal) ankle exoskeletons and a (proximal) robotic waist tether. ASB symposium on exoskeletons and prostheses.
- 2017 Exoskeleton actuation inspired by and informing biomechanics, BRB Seminar series, Omaha
- 2017 Optimization of exoskeleton actuation: Comparison of results with exoskeletons and exosuits, AHFE, Los Angeles
- 2014 Optimization of a simple Assistive Exoskeleton through human biomechanics experiments, Biodesign lab meeting, Harvard University, Cambridge
- 2014 Optimization of actuation and configuration of assistive devices for walking through human experiments, 7th World Congress of Biomechanics, Boston
- 2013 Effect of actuation and configuration of assistive devices, Lab visit, University of Michigan, Ann Arbor.
- 2013 Bipedal locomotion seminar, Carnegie Mellon University, Pittsburgh
- 2013 A simple exoskeleton can reduce the metabolic cost of walking. Dynamic Walking Conference, Carnegie Mellon University, Pittsburgh
Video: www.youtube.com/watch?v=qXIfHBH4ry0#t=8656
- 2013 A simple pneumatically powered exoskeleton can reduce the metabolic cost of walking, High Tech Systems, Eindhoven

Grants

Awarded

- 2021 NU Collaboration Initiative Perturbation-based, model-free metabolic time profile estimation for enabling devices and therapies to target costliest phases.
Role: PI \$38,000
- 2019 NIH COBRE GM109090 Exoskeleton optimization for reducing gait variability in patients with peripheral artery disease.
Role: subproject lead PI: Nick Stergiou
- 2018 Nebraska/NSF EPSCOR Dynamic Indirect Calorimetry.
Role: PI \$50,000
- 2018 University of Nebraska System Collaboration Initiative Exoskeletons for mobility assistance.
Role: PI \$8,500
- 2017 Industry consultancy grant: J Brasch Co. LLC
Gait-o-gram: differentiating fallers from non-fallers using nonlinear analysis.
Role: PI \$64,480
- 2017 Influence of foot-ground traction on gaits for reduced gravity, NASA Nebraska, \$24,092.

Submitted / Declined

- 2021 NIH R21: Perturbation-based, model-free metabolic time profile estimation for enabling devices and therapies to target costliest phases in older adults.
- 2019 NSF CAREER: Dynamic Indirect Calorimetry: Using wearable robotics to estimate the time profile of metabolic cost and make biomechanics tangible. Declined.
- 2019 University of Nebraska Collaboration Initiative seed grant: Clinically feasible hip exoskeleton design patients with PAD. Declined.
- 2019 NIH R15 Clinically feasible exoskeleton optimization for patients with PAD. Declined.
- 2018 NSF CAREER: Dynamic Indirect Calorimetry: Using wearable robotics to estimate the time profile of metabolic cost and make biomechanics tangible. Declined: ranked "medium competitive." (1x very good, 2x good, 1x fair)
- 2018 NIH R15 Hip exoskeleton facilitated therapy for improving mobility in patients with PAD. Declined: impact score 42
- 2018 University of Nebraska Collaboration Initiative seed grant: Hip exoskeleton facilitated therapy for improving mobility in patients with PAD. Declined.

Academic Outreach

2020	Nebraska Robotics expo
2019	National biomechanics day and Nebraska Robotics expo
2018	National biomechanics day and Nebraska Robotics expo
2017	Reddit AMA on Exoskeletons
2015	Family Day of Discovery, Harvard University: Soft Exosuit demonstration
2014	Kids university day, Ghent University: Lecture about biomechanical support of an elite high jump athlete
2009	Science night, Ghent University: Biomechanical support of an elite high jump athlete
2004-2014	Ghent University: Yearly open-lab days for high-school students

Media

2019	Media outreach for Report in Science covered by 102 news outlets with quotes in Scientific American, New Scientist, Boston Globe and The Telegraph. Attention score in top 1% of articles of same age https://www.altmetric.com/details/65022916
2017	Expert panel member on Reddit AMA session on exoskeletons
2017	Media outreach for Perspective article in Science https://www.altmetric.com/details/21274616
2017	Corresponding author for Science Robotics article on reducing the metabolic cost of running with a tethered exosuit including radio interview on NPR: Science Friday. Attention score in top 5% of all research scored on Altmetric https://robotics.altmetric.com/details/20735415
2017	Co-author on Science Robotics article on effects of assistance magnitude of a multi-articular exosuit. Attention score in top 5% of all research scored on Altmetric https://robotics.altmetric.com/details/15572794
2015	Citations of research in BBC website, The Economist and Popular Mechanics
2015, 2013	Two articles in Eos Magazine (Dutch and Belgian popular science magazine)

Memberships

Present International Society of Biomechanics
 American Society of Biomechanics
 American Association for the Advancement of Science
 Wearable Robotics Association
 Institute of Electrical and Electronics Engineers (IEEE)

Professional service

2021 Co-organizer Rocky Mountain American Society of Biomechanics

2019 Session co-chair at American Society of Biomechanics

2018, 2019 Session chair at Rocky Mountain American Society of Biomechanics

Referee services

Performed 70 manuscript reviews for
IEEE Transactions on Neural Systems and Rehabilitation Engineering, Scientific Reports,
Journal of the Royal Society Interface, Gait & Posture, Journal of Applied Physiology, European
Journal of Applied Physiology, Journal of NeuroEngineering and Rehabilitation, Biocybernetics
and Biomedical Engineering, IEEE RAS/EMBS International Conference on Biomedical
Robotics and Biomechatronics, Robotica, IEEE Robotics and Automation Letters, Plos One,
IEEE International Conference on Robotics and Automation, IEEE Transactions on Biomedical
Engineering, IEEE International Conference on Intelligent Robots and Systems, IEEE
International Conference on Rehabilitation Robotics, Royal Society Open Science, Science
Robotics
Review service record available on <https://publons.com/researcher/1217881/philippe-malcolm>