

## Abstract

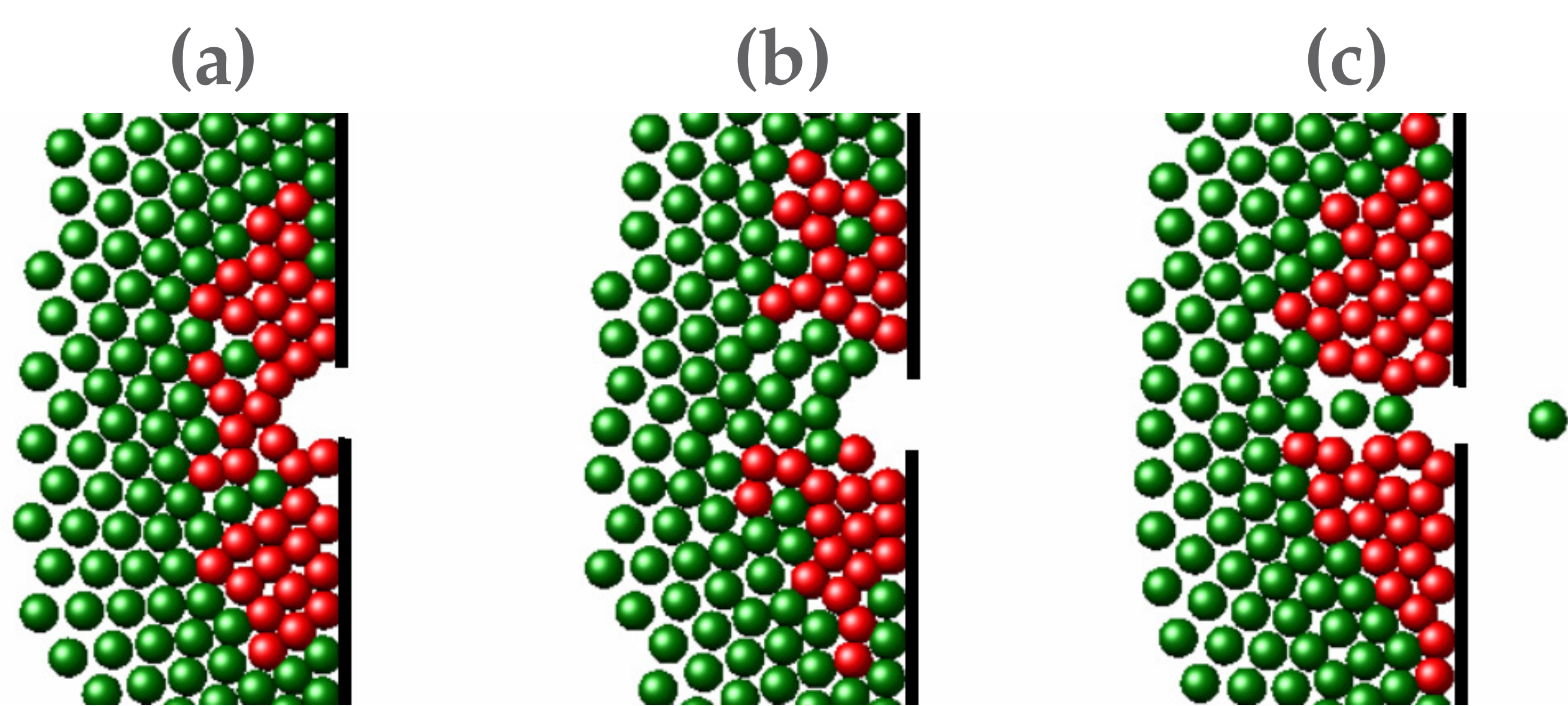
During an evacuation process, very high pressure levels can be achieved inside the crowd, raising to dangerous levels and causing unconsciousness of many individuals. We extended the basic social force model (SFM) to include fallen (unconscious) pedestrians, while the surrounding pedestrians may dodge them or skip them. We investigated both behavioural patterns. Dodge fallen individuals can produce evacuation situations from a completely blocked paths (due to fallen people) to free moving regimes. Instead, skipping fallen individuals may improve the evacuation process depending on the anxiety levels.

## The social force model (SFM)

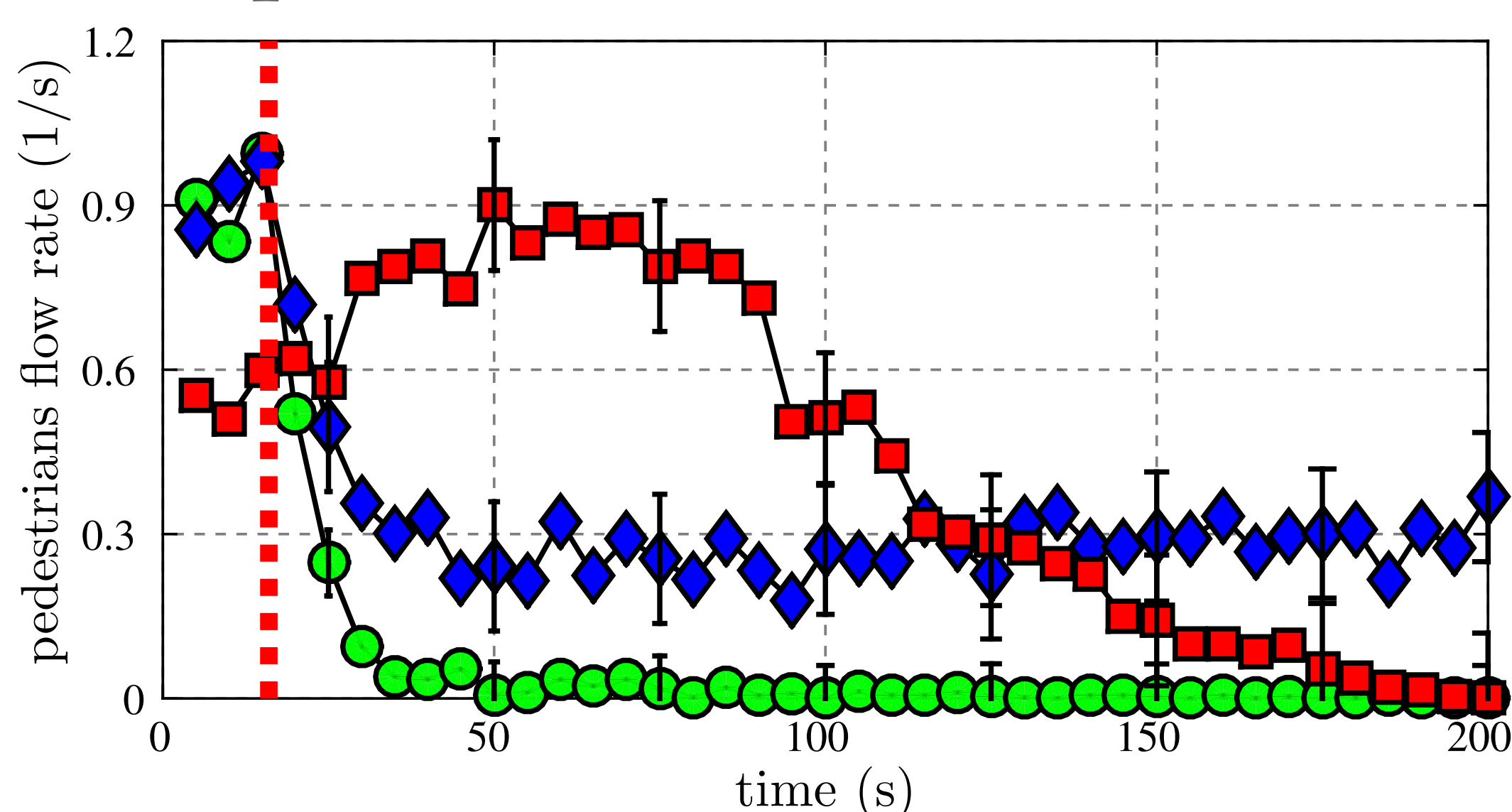
$$m \frac{d\mathbf{v}}{dt} = \mathbf{f}_d + \mathbf{f}_s + \mathbf{f}_g$$

- $\mathbf{f}_d$  is the desire force
- $\mathbf{f}_s$  is the social force
- $\mathbf{f}_g$  is the sliding friction

## Dodge fallen pedestrians



(d) pedestrians flow rate ( $v_d = 6$  m/s)



(e) probability of types

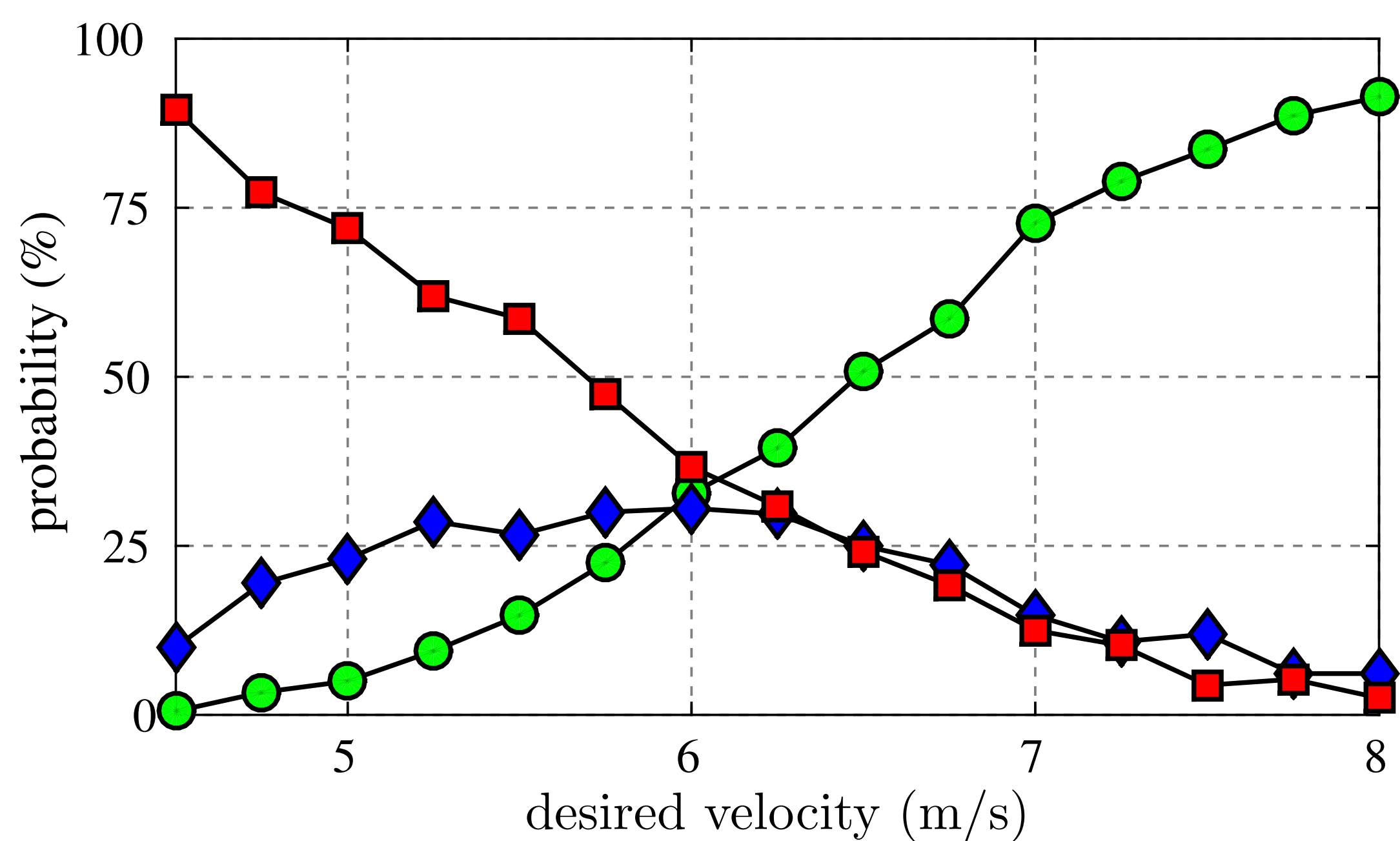
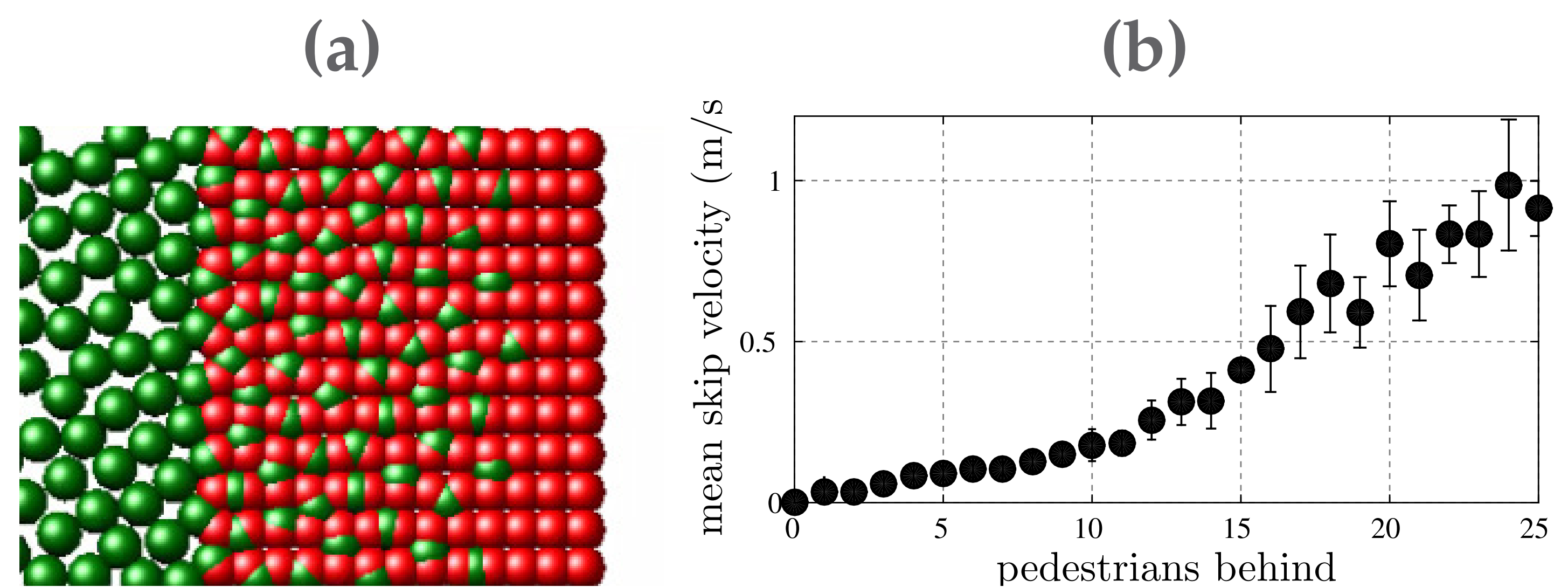


Fig. 1. (a-c) Pedestrians escaping through a door. Fallen people are coloured in red. (a) the exit is completely blocked. (b) wide channel. (c) narrow channel. The desired velocity is  $v_d = 6$  m/s. (d-e) The marks represents: ● blocked situation; ■ wide channel; ◆ narrow channel; ... time of maximum rate of fallen people.

## Skipping fallen pedestrians



(a) Pedestrians escaping in a corridor with a barrier of fallen people (coloured in red). (b) Mean skip velocity in the barrier. The desired velocity is  $v_d = 6$  m/s. and the skip velocity ( $v_s$ ) is  $v_s = 0$  m/s. (they don't intend to jump)

## Mean evacuation time

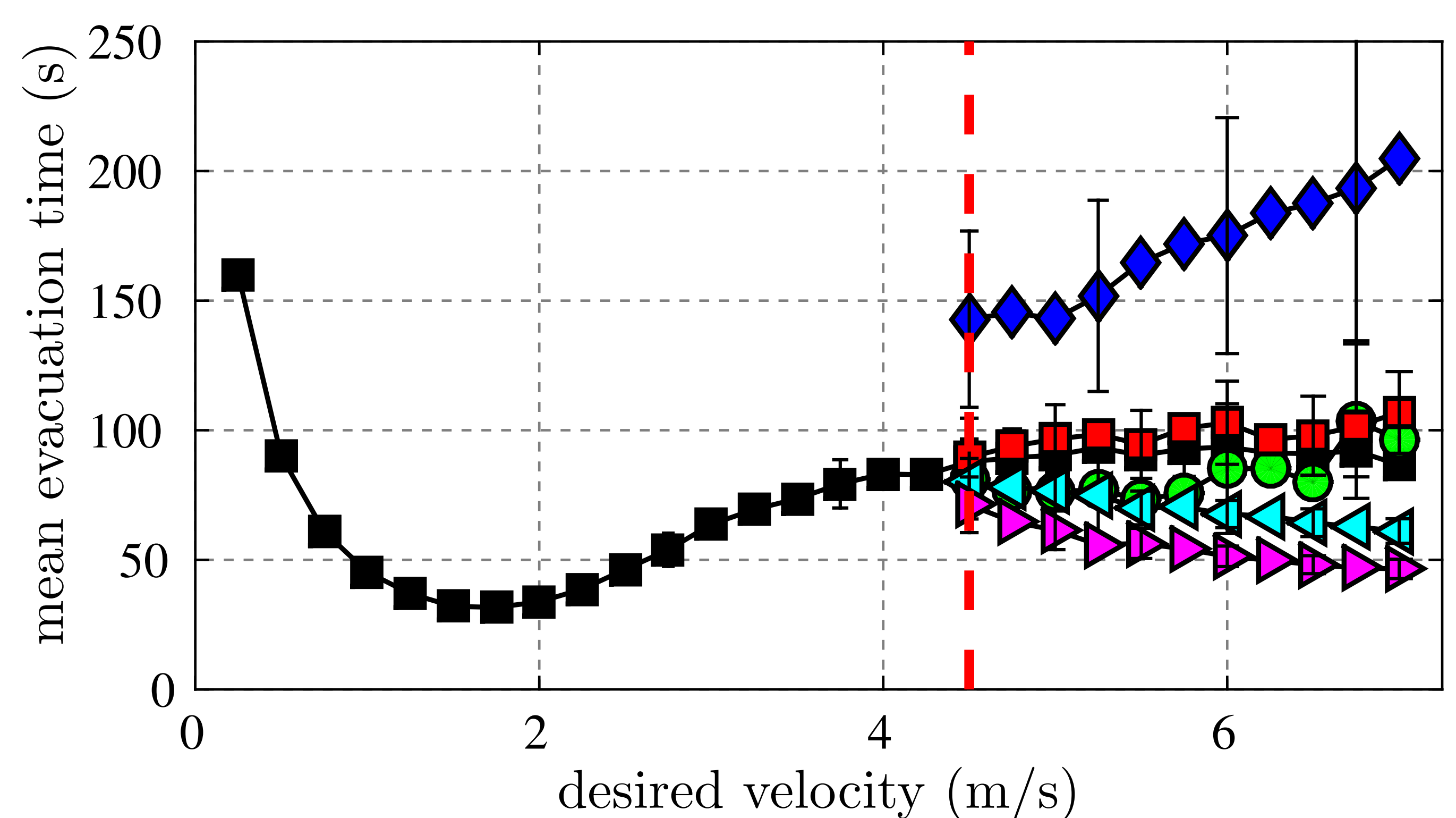


Fig. 3. Mean evacuation time for 100 pedestrians computed from 30 evacuation processes. ■ without fallen people; ◆ narrow channel; ■ wide channel; ●  $v_s = 1$  m/s; ▲  $v_s = 3$  m/s; ▲  $v_s = 6$  m/s; ... .

## Conclusions

- ✓ In the case of dodge fallen people, we identify three types of behaviours: formation of **blocking**, **narrow channels** or **wide channels** (view Fig. 1).
- ✓ Pedestrians that skip fallen people accelerate due the push of the individuals behind them (view Fig. 2).
- ✓ Skip fallen people improves the evacuation in comparison to dodge them (view Fig. 3).

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